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**The Mysore Coffee Experiment Station and what it is doing  
for the Improvement of Mysore Coffee.**

BY

**Dr. Leslie C. Coleman, M.A., Ph.D.,**

*Director of Agriculture in Mysore.*

The Mysore Coffee Experiment Station is situated in the Adigebail village of Kadur District and is about five miles from Balehonnur. The Station is about two miles from the Balehonnur—Koppa Road and is connected with it by a good station road which is passable in all seasons of the year. The station comprises 282 acres of land of which 82 acres are growing coffee 15—20 years old, 185 acres are jungle fit for growing coffee and 15 acres are waste land which have been utilized as a site for the buildings of the station. About 20 acres of the jungle have been cleared and planted with coffee during the past three years. The accompanying plan (Figure 1) shows the general plan of the station.

The station was opened in the year 1925 but progress was somewhat slow during the first two years. During the past three years

Fig. 1.

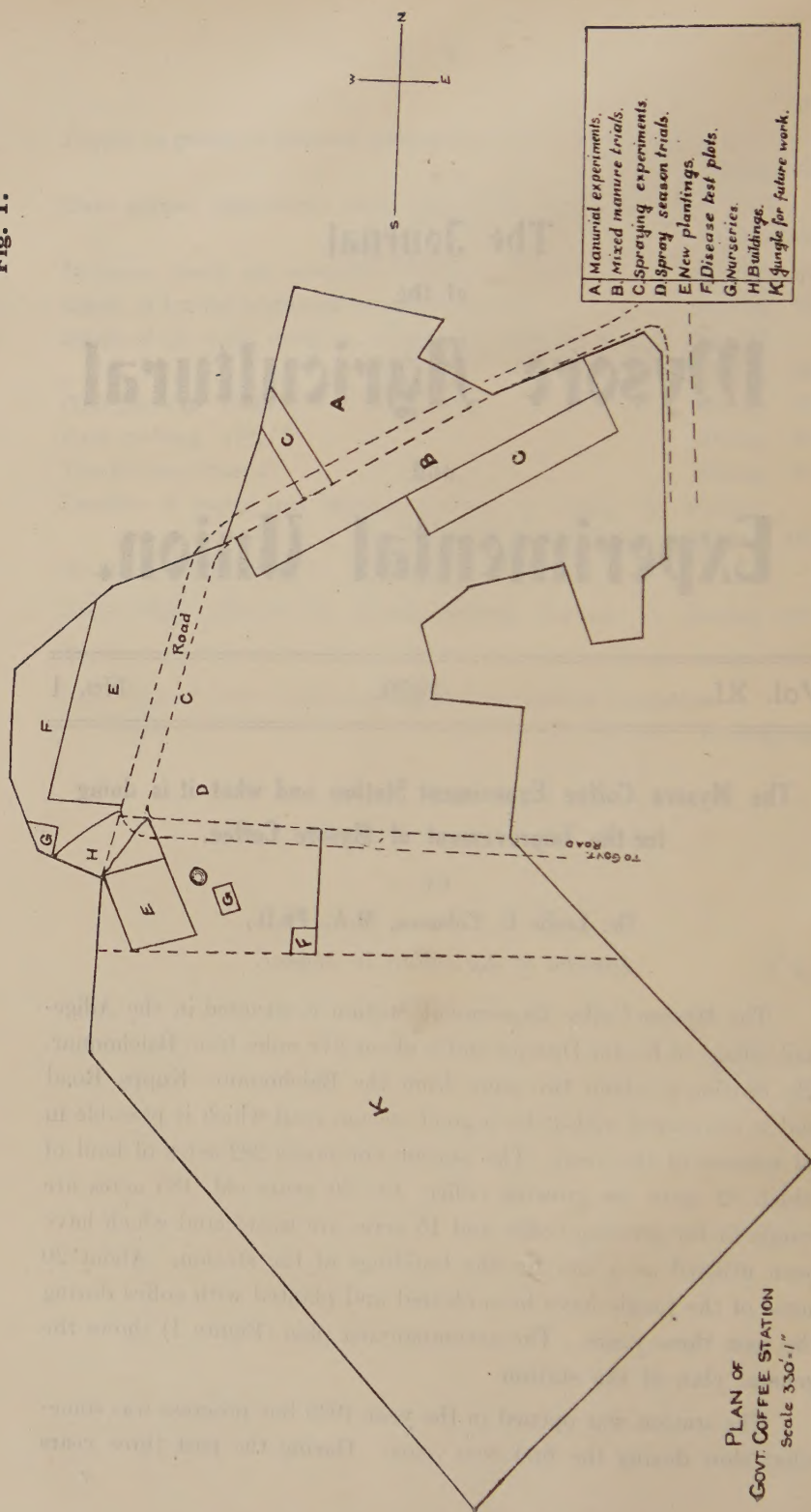
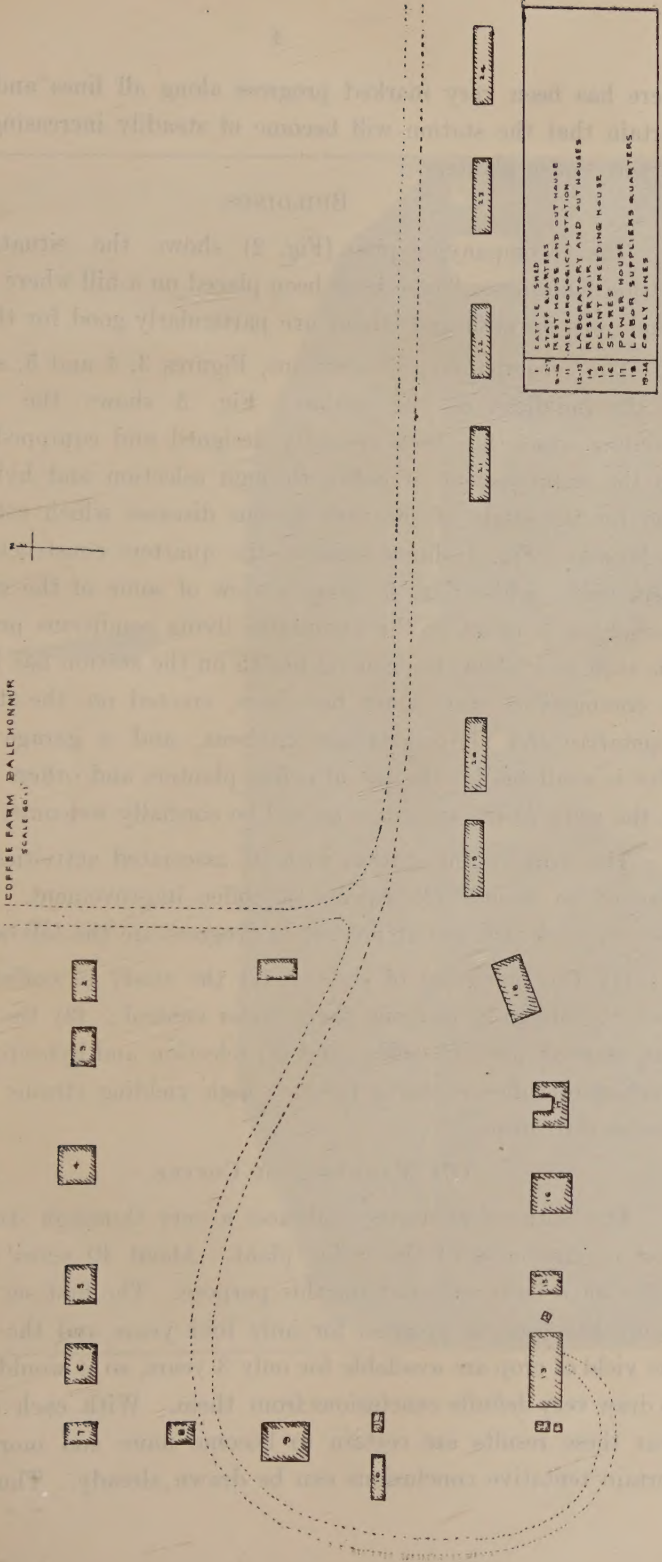


Fig. 2.

SITE PLAN OF BUILDINGS

COFFEE FARM, BALCHONNUR  
SCALE 1:500



there has been very marked progress along all lines and it seems certain that the station will become of steadily increasing value to Mysore coffee planters.

#### BUILDINGS.

The accompanying plan (Fig. 2) shows the situation of the station buildings. These have been placed on a hill where the health conditions for staff and labour are particularly good for the *malnad*.

The accompanying illustrations, Figures 3, 4 and 5, show some of the buildings on the station. Fig. 3 shows the laboratory building which has been specially designed and equipped for work on the improvement of coffee through selection and hybridization and for the study of the very serious diseases which attack coffee in Mysore. Fig. 4 shows some of the quarters constructed for the farm staff, while Fig. 5 gives a view of some of the cooly lines. Largely as a result of the favourable living conditions provided for the staff and labour the general health on the station has been good. A commodious rest house has been erected on the station with vegetarian and non-vegetarian kitchens, and a garage attached. This is available for the use of coffee planters and others interested in the work of the station, who will be cordially welcome.

The work of the station with its associated activities has been planned to include all aspects of coffee improvement. The main lines of work that are at present in progress are the following :—

(1) The manuring of coffee ; (2) the study of coffee diseases with the object of bringing them under control ; (3) the investigation of insect pests of coffee ; and (4) selection and hybridization and grafting of coffee so as to produce high yielding strains which are resistant to disease.

#### THE MANURING OF COFFEE.

The work on manuring embraces a very thorough study of the food requirements of the coffee plant. About 40 acres of mature coffee have been set apart for this purpose. The first set of experiments has been in progress for only four years and the effects on the yield of crop are available for only 3 years, so it would be unsafe to draw very definite conclusions from them. With each succeeding year these results are certain to become more and more definite. Certain tentative conclusions can be drawn already. Thus it seems

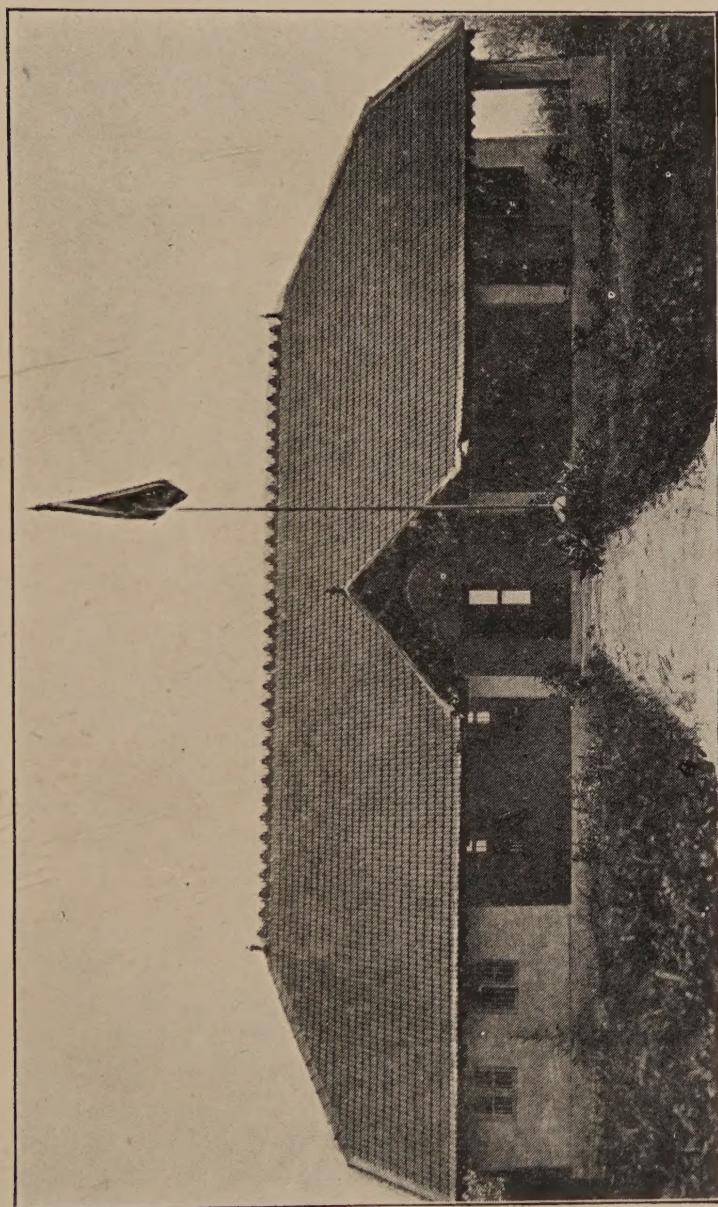


Fig. 3—Coffee Experiment Station—Research Laboratory.







Fig. 4—View of the Staff Quarters.



Fig. 5—General View of some of the Coolie Lines.

certain that the application of bonemeal to coffee which has been so generally practised in the past gives much poorer results than the application of a readily available phosphatic manure, such as superphosphate. It also appears that a readily available nitrogenous manure such as ammonium sulphate gives better results than does an oilcake such as groundnut oilcake. As ammonium sulphate is a much cheaper manure than oilcake when we take into account the content of nitrogen this is a matter of very considerable importance. The view quite commonly held by planters that artificial manures simply act as stimulants to the plants and that there is some special virtue in slow acting manures such as oilcakes and bonemeal is not supported by the results so far obtained. Sodium nitrate has been added to the series of experiments only within the last two years ; so it is not possible to make any statement as regards its relative value.

Experiments with combined fertilizers such as Ammophos and Monammophos have just been commenced. It is, I think, quite safe to say that within another two or three years we shall be able to give coffee-planters definite advice on manuring which will enable them to obtain better results with a reduced expenditure of money.

#### PLANT DISEASES.

The study of plant diseases has, as its object, the economic control of the disease but a necessary first step must be the study of the cause of the disease and the conditions which favour its appearance and spread. We are being greatly helped in this work by the presence of Mr. W. W. Mayne who is employed by the United Planters' Association of Southern India to work under the direction of the Director of Agriculture on the Station. Mr. Mayne is devoting the whole of his time to a study of such important diseases as leaf disease, die back and root rot. Black rot, one of the most serious diseases of coffee, has already been thoroughly investigated by the Agricultural Department and it has been shown conclusively that this disease can be completely controlled by spraying with Bordeaux mixture during the two months directly preceding the south-west monsoon. The study of 'die back' has shown with a fair degree of certainty that this disease can also be controlled by spraying. Leaf disease can be controlled by the same means. In the case of die back and

leaf disease it appears likely that two sprayings a year—one in April or May and the other in September or October—will be necessary to give thorough control.

The effect of spraying is very marked. Planters who have been carrying out spraying operations on a fairly large scale state that it has increased their crop by an average of two hundredweights of coffee per acre while the spraying has cost in most cases less than the value of half a hundredweight of coffee. Even at the present somewhat reduced prices this represents an increase in the net return from coffee of nearly Rs. 100 per acre which, if it were spread over the whole coffee area in Mysore, would bring an increase in crop value of one crore of rupees per annum.

It will, no doubt, take some time before the practice of spraying will spread to all the coffee grown in the State but the rapidity with which it has been taken up by coffee planters, both Indian and European, during the past two or three years has been quite remarkable. Three years ago there could not have been more than 500 acres of coffee sprayed in the State. During the present year the area has arisen to more than 5,000 acres which must have led to an increase in the value of the crop by at least Rs. 4 lakhs. About 40 planters are known to have taken up spraying during the past year while the number is probably considerably more than this. Of these over twenty are Indian planters. A total of 240 small sprayers have been sold while three motor sprayers have been procured and supplied to one of the most important Indian planters. The accompanying Figs. 6 and 7 give two views in a coffee estate which has been very thoroughly sprayed and where high yields have resulted (an average of  $6\frac{1}{2}$  cwts. per acre over 400 acres).

Fig. 6 gives a general view to show that while the coffee is bearing a heavy crop it has retained its leaf to a remarkable extent. Fig. 7 gives a close view of coffee trees bearing a very heavy crop and at the same time retaining a large number of leaves so much so that the crop is hardly visible in the picture.

The Agricultural Department is paying great attention to providing facilities for spraying to Indian planters and more especially to planters who own small areas. To enable these planters to obtain material and sprayers readily, depots have been opened at Tarikere, Chickmagalur and Saklespur. Government have also sanctioned a



Fig. 6—General View of a portion of a Coffee Estate thoroughly sprayed.



Fig. 7—Close View of Sprayed Coffee Bushes.  
Note the heavy crop and the large number of leaves retained.







Fig. 8—Charging a Battery Sprayer (Holder Fix No. 1) with the mixture contained in the barrel.



Fig. 9—Spraying with a Battery Sprayer.

scheme where coffee planters can purchase sprayers and spraying materials on credit, the amount to be collected at the end of the following crop season. The appointment of Dr. M. K. Venkata Rao as Deputy Director of Agriculture for the planting areas will enable a much more thorough organization of spraying demonstrations than has been possible heretofore and I anticipate a very rapid expansion in the area sprayed in the immediate future.

The work on the station in connection with spraying is twofold. In the first place various different kinds and strengths of spray mixtures are being tested with the object of ascertaining which mixture combines to the greatest extent efficiency with cheapness. In the second place various different types of sprayers are being tested with reference to their efficiency and suitability for large and small estates. Figs. 8—11 show different types of sprayers in use for spraying coffee. Fig. 8 shows a battery sprayer being charged with spray mixture. Fig. 9 shows the same sprayer in use on coffee. Fig. 10 shows a Drake & Fletcher Headland sprayer in action. Fig. 11 shows a Holder motor sprayer which is being tested for its suitability for coffee spraying. An attempt is being made to induce important manufacturers of sprayers and spraying machinery to send samples of their manufactures to the station for testing. If we are successful in this we should, within the next two or three years, be able to advise coffee planters as to the most suitable types of sprayers for their particular conditions.\*

As already stated, it has been established that the three serious coffee diseases can be effectively controlled by spraying. The control of root rot is a more difficult question. The root rots of coffee are at present being studied by Mr. Mayne and it seems just possible that spraying may have an indirect effect in bringing them under control. However a more promising line of attack is the production of varieties with a resistant root system. It is generally recognized that both Robusta and Liberica coffee are much more resistant to root rots than the Arabica types generally grown in Mysore. It seems probable therefore that hybrids of Arabica with one or both of these other species of coffee can be produced which will be highly

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\* A bulletin on the "Spraying of Coffee" is under preparation and will be published shortly.

resistant to root rots. The production of such hybrids will take time and in the meantime another promising method of control is being attempted. This method is to graft Arabica coffee on to root stocks of Robusta and Liberica. Experiments in this connection have been in progress on the station for the past two years. The experiments have been planned to ascertain the best season for grafting, the most suitable age of material to use and the grafting method to be followed which, while remaining simple so that it can be taught to an ordinary cooly, will, at the same time, give the largest number of successful grafts. Very promising results have been obtained during the present year and it seems probable that a method will be worked out which will enable a gang of two men (one grafter and one helper) to make about 100 successful grafts per day. As the favourable grafting season extends probably over a season of about three months, two men should be able to produce material in one season sufficient for the planting of 5 acres. Figs. 12 and 13 show the grafting work in progress in the station nursery. The glass tubes are inverted over the plants after the grafting is done to prevent drying out. The use of these tubes has greatly increased the success of grafting work.

Grafting of coffee will serve another valuable purpose in addition to providing plants resistant to root rot. It will enable coffee planters to propagate from trees in their estates which consistently give the highest yields. This will give them plants both for supplies and for new plantings which are certain to yield well, something which cannot be assured in the case of plants raised from seed.

#### INSECT PESTS.

If we turn to a consideration of the insect pests that attack coffee there are two of serious importance. These are coffee green bug (*Coccus viridis*) and coffee-borer (*Xylotrechus quadripes*). The Department has already worked out an effective method of control for the first of these. This is spraying with fish oil resin soap which was first introduced by the Entomological Section of the Department in the year 1914 and which has been the standard method of control ever since. As regards coffee-borer not so much progress has been made. However, the collection of the beetles as they emerge, which has been advised by our Entomological Section, undoubtedly tends



Fig. 10—Drake and Fletcher Headland Sprayer in action.



Fig. 11—Motor Sprayer (Holder), with four long hose attachment.







Fig. 12—Grafting of Young Coffee Plants in the Nursery.  
Inverted glass tubes protect grafts from drying.



Fig. 13—Grafted Coffee Plants four months old.

to bring this serious pest under control. Scrubbing of the stems to prevent the laying of eggs which has been recommended by the Entomological Section is being followed by a number of planters. Some promising methods of stem treatment to prevent the laying of eggs are under investigation. The possibility of destroying the eggs and the young larvæ soon after hatching by a spray or wash applied to the stems is also being studied. It is known that the adult beetle of the coffee-borer prefers exposed and unshaded areas for laying eggs and it seems quite probable that spraying, which enables the coffee bushes to retain their leaves, will serve as a means of controlling coffee-borer also.

#### PLANT BREEDING.

The improvement of Mysore coffee by selection and hybridization forms one of the most important items of work of the coffee experiment station. A necessary first step has been the collection of seed from high yielding trees of Arabica coffee from as many different estates and areas as possible. These have to be grown in plots side by side to enable us to study their growth, resistance to disease and production of crop. In addition, seed of as many different species and varieties of coffee as can be obtained has been collected and plants are being raised from this seed. We have at present on the station material from almost 200 selected plants collected in most of the coffee-growing areas of South India. In addition we have material of most of the coffee species which are being grown commercially in various parts of the world.

By the end of the present calendar year we shall have about 15,000 trees or approximately ten acres planted with seed from what must be looked upon as about the best individual coffee trees which are growing in South India. From this huge mass of material it seems certain that we shall be able to make selections of outstanding merit. The seeds from a few of the oldest of these plants are being procured by self-fertilization this year while other flowers on the same plants have been cross-fertilized with selected Robusta plants.

As one of the main objects of our breeding work is to procure new strains which are resistant to disease, no spraying is being done on the breeding area. Selections will be made from those plants which promise regular high yield and which at the same time show the least attack of such diseases as 'die back' and 'leaf disease'.

Our selections will be still more severely tested by growing them under conditions such as to favour the development of the various important coffee diseases.

As already stated, our first selections have just been made and from now on we should each year have an increasing number of plants from which to make selections. I anticipate that within ten years' time we should have reached a stage when we shall be able to start distributing seed for trial to coffee planters. Every effort will be made to speed up this work but it is work which, in the nature of things, requires time. That the results of this work will be of very great value to coffee planters seems to me quite certain.

#### DEMONSTRATION WORK IN CONNECTION WITH THE RESULTS OBTAINED ON THE COFFEE EXPERIMENT STATION.

A very considerable amount of demonstration work has been carried out during the past two years in connection with spraying for the control of coffee diseases. A certain amount of demonstration work on the control of coffee-borer has also been conducted. The services of the Agricultural Chemist have also been requisitioned by a number of planters in connection with the manuring of coffee. In connection with work on different varieties and species of coffee it is important to mention that trials of Robusta and Arabica coffee have been started on the Marthur Farm in Shimoga District. The growth of Robusta plants has been distinctly promising. If we succeed in our trials with this coffee, as I believe we shall, it will open up possibilities of developing a very large *malnad* area which at present is practically dependent upon arecanut and paddy for its agricultural production.

It is fully realized that unless the results of our experimental work can be carried to the coffee estates, large and small, of Kadur and Hassan Districts the station cannot be said to have justified its existence. As I have already pointed out, the spraying on coffee estates which has been very largely due to the efforts of the Department is already leading to an increase in crop valued at about Rs. 5 lakhs per annum. The advice on manuring based largely on results obtained on the station is also benefiting coffee planters. However it has been felt that much more intensive efforts are required in connection with our demonstration work. With the object of organizing and intensifying this work throughout our whole coffee area

Government have recently established a separate circle consisting of the taluks of Kadur and Hassan districts where coffee planting is extensively carried on. Dr. M. K. Venkata Rao, who has heretofore been in charge of the Coffee Station, has been placed in charge of this Circle with headquarters at Chickmagalur. To ensure efficiency on the station itself there has been recently appointed as Manager, Mr. K. H. Sreenivasan, a graduate of Edinburgh University, who has had several years' experience in the management of a group of coffee estates. Dr. Venkata Rao will have under his charge at once a staff of 4 agricultural inspectors and 8 fieldmen and I trust that this staff will be considerably strengthened in the near future. Each of the inspectors is in charge of a depot where sprayers and spraying materials will be stocked for the benefit of the smaller planters who are not in a position to order large quantities direct from main suppliers. This staff will be used very much more intensively for the benefit of coffee planters than it has been in the past and I anticipate as a result that there will be a very rapid adoption of the methods of manuring and of disease control recommended by the Department as a result of investigations carried out by the Department. It is our intention to enable every coffee planter in Mysore, large or small, to make use of the information and results which are being so carefully collected by intensive scientific work on the Mysore Coffee Experiment Station.

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### **The Cultivation of Pepper in the Mysore Malnad.**

BY

**A. K. Yegnanarayana Iyer, M.A., Dip.in Agri. (Cantab.), N.D.D.,**

*Deputy Director of Agriculture in Mysore.*

From time immemorial the wealth of the Mysore *malnad* has consisted of its special products—arcanut and pepper, and of these pepper has the distinction of having a world-wide market unlike the arcanut, the demand for which, though large and lucrative, is still confined largely to our own country. Coffee is a comparatively very recent addition to the special products of our *malnad* and though latterly it has contributed to the prosperity of the tract more than any other crop, still the menace of Brazilian coffee and of the

ever-present diseases always hang like a Damocles' sword over the industry. The very high prices which have been ruling for the last few years for pepper which have reached and kept at the unheard of level of Rs. 25 per maund has made pepper unique among these products and though this may be considered an exceptionally favourable phase and not likely to last for long, still it has always remained even prior to these days of soaring prices a specially high priced crop with a steady and unfailing demand.

The Mysore *malnad* furnishes moreover some of the best conditions for the cultivation of this crop. During about eight months of the year the rainfall conditions resemble those that obtain in those parts of the tropics which are the home of the pepper, and during the remaining four months of the year, the irrigation facilities together with the moisture conditions of the atmosphere prevailing in the arecanut gardens in which the pepper is grown largely as a subordinate crop afford ample facilities for growing the crop to perfection. In respect of altitude practically the whole of the *malnad* permits of the cultivation of the crop, as is evidenced by the pepper growing wild in the jungle, as well as in the estates here and there throughout the tract where it is seen to grow well, having been put out and trained over shade tree standards on the cleared and planted hill sides.

It is a matter for surprise then that the cultivation of pepper is not receiving the attention that it deserves. In the arecanut gardens, though a well-recognized and important subordinate crop, its cultivation is anything but universal, large portions of such gardens are not planted at all, while where it is fully planted, the attention paid to it by way of manuring, renovation, pruning, etc., fall far short of the requirements. As regards extension of the planting into *kans* and jungles, usually selected for plantations, the scope may be said to be unlimited, as the little that has been attempted and achieved here and there is nothing as compared with what can be done.

With a view therefore to arousing interest in this lucrative and important crop for which there is such great scope in this State the following brief account of the cultivation of pepper is compiled for publication in the pages of this Journal.

Pepper belongs to the order of plants which are mostly climbing shrubs and which are included in the family of which the most important are *Piper nigrum* (Black pepper) which is the subject of this

account, *Piper betle*, the well-known betel leaf vine (*Pan*) and *Piper longum*, the pippili or hippili, that all-important drug in native Indian medicine. In ordinary English, Pepper (*Piper nigrum*) is to be distinguished from the totally different product also called pepper, but qualified as long pepper, Cayenne pepper, red pepper or capsicum pepper. Whatever its country of origin, the region of the Western Coast of Peninsular India including the hill sides or valleys of the ghats, extending from Konkan in the North to Travancore in the South has long been recognized as the home of the pepper. The pepper of Malabar indeed has a reputation for quality not shared by pepper from any other part of the world. Throughout the East Indies, Malaya, the Straits Settlements, Java and the Dutch Indies pepper is grown extensively and ranks as one of the most important products of export. Ceylon and to a small extent, Eastern Bengal and Assam are minor areas of production. It has thus a wide range of cultivation, being grown in these different countries practically from sea level to altitudes up to even 3500 feet. A moist heat typical of what obtains in the wooded and sheltered valleys of the *malnad* is required for the crop, while in regard to rainfall, a heavy precipitation ranging from 70 inches up to 200 inches and over in the year is characteristic of the tracts of pepper cultivation. The proximity of the equator which is an advantage possessed by countries like Ceylon and the Straits Settlements, and which gives these countries a rainfall throughout the year with no rainless month at all makes these specially favoured regions for the cultivation of this crop.

Throughout South India, the soils on which pepper is grown are more or less the same, being the typical laterite of these localities weathered and disintegrated, deep red in colour and with a large admixture of both fine and coarse highly ferruginous earth. Light coloured soils derived from the ordinary gneissic rocks are also met with. In both cases surface soils in the well-wooded forest areas and hill-side estates are enriched by leaf mould and other vegetable debris which give the soils in such situations a somewhat darker colour. The former or red laterite soils usually strikingly mottled red and white, however, predominate, which though naturally poor are rendered fit by heavy manuring with cattle manure enriched by the addition of green leaves. In the East Indies the pepper soils are said to be very rich in humus or, if they are lacking in the same, to be

artificially enriched and brought into such a condition. In any case soils rich naturally or heavily manured are indicated, a feature which the crop shares in common with its near relative the betel leaf vine.

Drainage is equally essential, a fact which is often strikingly illustrated in the poor and sickly condition of many *malnad* gardens which may for some reason or other have suffered neglect. This is specially important, as the tracts where pepper is usually grown are all regions of very heavy rainfall and soils tend to become soaked and sodden unless deep and well-laid drainage channels are provided. In general, drainage is well provided for and the situation of the gardens also admit of thorough drainage, except where the valleys are level and shallow and situated immediately above the water-spread of the irrigation tank lower down into which the surface flow of the garden drains and often backs up choking the drains altogether. Like the betel vine too, the pepper vine requires shade and a sheltered situation. Being a climbing vine, both in nature in its wild state and under cultivation, a certain amount of shade is of course afforded by the standards on which the vine has to climb. As grown in the arecanut gardens, the shade is provided by the areca trees themselves on which as standards the pepper vine climbs: as grown in the open as in plantations, the same purpose is served by the shade trees left for the purpose or planted specially. It is very seldom that other standards like dry poles are used, though it is stated that in the very intensive pepper cultivation carried on by the Chinese in Malaya, only hard wood posts are used as standards. Just how much shade is necessary is a matter on which growers have different opinions. Reduction of shade is often reported to result in an increased yield, and that pepper grown in the open yields more than when it is grown under the conditions of the areca gardens, where the shade is naturally very heavy. In the latter method of cultivation which by far is the more important of the two at any rate with us, this question does not arise at all as the pepper has to be grown only in that particular manner. Even when grown by itself as in plantations the conditions are such that considerable shading will be required, erring on excessive shading rather than on the lack of it: the period from January to April is really a trying one: it is practically completely rainless and without the cooling shade afforded by standards and shade trees, the drying weather may do irreparable damage. Even during the rainy months,

the shade trees will mitigate the driving and beating by the heavy rains of the *malnad* monsoons.

Shelter against the western sun which is always very severe in these regions is also a very desirable provision to strive for. Steep valleys running north and south or valleys and hill-sides with an eastern aspect will naturally afford this kind of shelter; on gardens and estates not possessed of this natural advantage, the same protection will have to be arranged for by other methods, such as a high shade belt on the western side. For the same reason, it is also a general recommendation in pepper planting, that the planting be made generally on the eastern side of the standards, which, should they be large trees, will protect the vines even when full grown, like a protecting wall against the western sun.

As may have been seen from the above, pepper in Mysore and throughout the South Indian pepper region, is grown in two ways, viz., (1) as a subordinate crop in existing arecanut gardens, the areca trees themselves being used as standards to train the vines on, (2) as a pure crop by itself or in conjunction with coffee in natural jungle cleared and planted, standards being furnished by jungle trees and by trees specially planted for the purpose. Somewhat very similar to the latter is the growing of the vines on a small scale, more or less to meet household needs, on trees like the mango and the jack in the compounds or immediate vicinity of dwelling houses where with the special attention it naturally receives it brings in a substantial addition to the income of the family.

The first method is practically the most general, and though individual holdings may be small, the aggregate area should be very large; for though the area under pepper as such is not given in the returns, some idea may yet be got from the area under arecanut in the *malnad taluks* of Shimoga and Kadur which is given as nearly 25,000 acres and a good part of such gardens probably contains pepper as well.

The planting of pepper vines in these gardens is carried out in the following manner :—

Branches from a well-established and bearing vine springing from a short distance of about a foot or two from above ground are laid flat on the moist ground with the growing point towards one of the adjoining areca trees on which a new vine is to be

trained. The vine is covered over with the moist earth over that length so as to cover one or two nodes from where rooting is encouraged. As the vine thus layered grows in length, the growing end is tied to the areca stem selected and when the rooting which is quick and profuse is sufficiently strong the layered vine is severed from its parent. This method of layering and planting can obviously be applied only in the case of areca tree standards adjacent or very near to the parent vine. In the case of other standards, vines similarly layered are removed in the same manner and planted wherever they may be required in the garden. The planting is generally done during the monsoon rains in the months of June and July during intervals when there may be a break. As rooted vines like the above cannot be had in large numbers, ordinary cuttings themselves are taken from such branches, as well as from the thinnings from the crown of the bushes. Individual cuttings used as planting material are from three to four feet long with at least that number of nodes. In well-prepared and manured pits dug close to the standard selected the cutting is planted laid flat about 8 inches deep in such a way that all but two feet is below ground. Only one cutting is planted under each areca standard and very seldom more. Growth starts generally about the following October but the failures with such cuttings are very large indeed. This is especially so in the case of cuttings from the crowns but on the other hand they are said to give rise to better yielding plants than the suckers or branches from below: to what extent this view is correct cannot be stated in the absence of tests on the Government Farms. Where planting is proposed of pure pepper on jungle land, the planting of the pepper has to be preceded by the preparation of the ground and the raising of the standards. The jungle is first felled and cleared, retaining some of the natural shade trees, which could at the same time serve as standards as well. From what I have seen so far I think it is imperative in this climate that some of the natural shade should be retained. A wholesale felling as is illustrated by the accompanying photograph is almost sure to be very detrimental and to prove a liability which will take a long time to wipe off. The raising of standards is the next step. The different species *Erythrina* such as *indica*, *lithosperma* and the *striata*, are the general favourites for this purpose in all the pepper growing countries. It is however a

slow business, if it has all to be grown from seed. In Malabar during the three or four years that it takes for the standards to attain the required height and girth, hill paddy is said to be raised on the clearing so as to keep it under some kind of cultivation and to obtain a small return. Circumstances may not always admit of this procedure, and the only alternative will be to procure good green wood poles of the *Erythrina* at least two inches in diameter so as to get an early start. The sowing of the seed both in the estate itself and on the outskirts to provide later on standards and cuttings is also taken up and carried out simultaneously.

The suitable distances for planting standards admit of much variation somewhat in the same way as with coffee, and not as in the case of the ordinary agricultural crops or even a plantation crop like cocoanut, for instance. In the areca gardens the distance varies from 6 feet to 18 feet, while in pure pepper plantations 8 to 12 feet is usual as in Malabar while a closer planting at 7 feet intervals is also adopted as in the Straits Settlements. Where the standards selected are large trees such as the mango or jack, four or five cuttings are usually planted under each. Rectangular pits one foot deep and one foot wide and 2 to 3 feet long are dug at the foot of the tree on its eastern side and filled with good earth, cattle manure and leaf mould, and in these the cuttings are planted in the same way as for other standards.

Before leaving the subject of planting methods it will be of interest to observe that according to the system in vogue at present, the number of cuttings which fail to strike root is excessively large and perhaps almost disastrously so. This means not only a great waste of planting material but, what is really much more serious, the loss of a whole season. This is the experience in all pepper gardens both here and in Malabar. In the Marthur Farm itself, off and on from the year 1917 onwards, pepper cuttings intended for planting have been got out from various parts of the country and planted, aggregating to several thousands but what has survived out of these is a very small number indeed. In the work of importing pepper cuttings of the better yielding varieties from Malabar and distributing them on a large scale in the Shimoga *malnad* which our Department has been engaged in for the last three years the experience has been the same. Out of the nearly two lakhs of cuttings

distributed so far, it is doubtful if even a third has established itself. It is a question for consideration therefore whether the cuttings should not be put out in a nursery in the first instance and later on only robust and fully rooted plants put out in their permanent places. Indeed this is the practice which is said to be largely adopted in the Chinese pepper gardens in the Straits Settlements. It will be a useful practice if every garden owner should have his little nursery for pepper, somewhat after the manner of the coffee planter but of course on a very much smaller scale. Basket plants can be raised and these can be put out even towards the end of the monsoon say in September, or even during the heavy monsoon as is done now in June with the certainty of its ability to survive. Even for purposes of general distribution by sale a central nursery will serve a very useful purpose.

One intelligent garden owner gets his planting material by "marcotting" branches of the vine at the crown, *i.e.*, by encouraging rooting of the node by slightly slitting the bark and tying a little moist earth around it with a wide strip of areca sheath. Done in June, the rooting is profuse by August and the branch is ready for severing from the parent vine and planting in September. This is a clever and useful way of getting over the difficulty and is fully worthy of being copied. The planting material consists, according to Mysore and Malabar methods as already indicated, of the lower branches springing close to the base of the bush generally, and when larger numbers are required, of the branches from near the crown. In the Straits Settlements on the other hand, the latter is said to be preferred: whether the high yields of 3 to 3½ lbs. of dry marketable pepper per vine said to obtain there is the result to some extent at least of this practice, cannot of course be said. The methods there are indeed so different, that it is worth being given in a little detail. The vine is propagated from cuttings selected from the tops of the best yielding vines; the cuttings which are one foot long are planted in well prepared nursery beds and buried six inches in the ground. The beds are shaded and watered carefully when necessary. In a year, the cuttings are established and are fit for transplanting. When ready for transplanting they are lifted from the nursery and planted a few inches from their supports, facing east. (From the *Malayan Hand-Book of Agriculture*.) We have unfortunately no result of experiments to show

whether and to what extent such planting material is really conducive to a better yield. But the experience of Mr. Subramanya Bhatta of Tenginkere who compared the two methods of planting confirms in a general way the above view regarding the high yields obtainable from such cuttings.

*(To be continued.)*

## **The Engineer and Agricultural Development.\***

BY

**Dr. Leslie C. Coleman, M.A., Ph.D.,**

*Director of Agriculture in Mysore.*

It is with a great deal of diffidence that I appear before you. I have myself had to suffer so frequently from speeches on my own subject delivered by men who knew nothing about it, that I am particularly sensitive to the possibility of my trespassing upon ground where I have no business to be. I take heart from the remembrance that Mysore audiences are particularly courteous in their attitude to speakers and from the feeling that if I wander from the path which I should follow, you will not deal harshly with me.

There is, I believe, no other class of people in Mysore whose lives have been so widely and beneficently affected by the work of the Engineer as the agricultural class. The improvement of communications and the development of irrigation have been for many years and still continue to be among the most important lines of work occupying the attention of engineers in this State and upon both of these depend, to a very large extent, the happiness and prosperity of our agricultural population.

Of these two subjects, I propose to speak of irrigation as it is that particular phase of your work which comes most intimately into touch with the work of the Agricultural Department.

A comparison of the irrigated area in Mysore with that in British India seems to indicate that we are not unfavourably situated. The figures given in the chapter dealing with irrigation in the Report of the Royal Commission on Agriculture show for British India in 1925-26 a total of 50,813,000 acres as the gross area irrigated out of

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\* Inaugural Address to the Mysore Engineers' Association at Bhadravati on the 14th February, 1930.

256,991,000 acres as the gross area sown. This gives 19.8 as the percentage irrigated of the area sown.

The figures in the *Mysore Season & Crop Report* for 1925-26 show 1,086,653 acres irrigated out of 5,239,298 acres sown. This gives 20.7 as the percentage irrigated of the area sown. Our conditions are, however, not so favourable as these figures suggest, for if we analyse the area irrigated according to the sources of irrigation, we find almost exactly one-third of it is irrigated from what are classed in the *Season & Crop Report* as 'Sources other than canals, wells and tanks'. These "Other Sources" are undoubtedly, in most cases at least, precarious sources of irrigation water. We find further that our area under tanks represents 46.7% of the total irrigated area while canals and wells provide water for only 12.2% and 7.8% of the total respectively.

While it is perhaps unsafe to generalize as regards the relative merits of different sources of irrigation water I think we shall be fairly safe in saying that tanks are on the average not nearly such assured sources of irrigation water as are canals and wells. We have then a situation where 80% of our irrigation is derived from somewhat precarious sources while only 20% comes from moderately assured sources.

The conditions in British India are on the average very different and in no province of British India do we find conditions at all comparable with those that exist here. The average figures for British India show 51.1% under canals against our 12.2%, 24.2% under wells against our 7.8%, 13.1% under tanks against our 46.7% and 11.6% under other sources against our 33.3%.

It is true that the irrigation works now in progress will considerably alter the proportions under the various sources of irrigation. The Irwin Canal Scheme alone will, when it is completed, almost double the area under canals and will bring the area under this source of irrigation upto something over 20% of the total. Our tanks will, however, continue to supply water to about 40% of our irrigated area and, as far as one can see, are certain to remain our main source of irrigation water for very many years to come.

From an agricultural standpoint there are two reasons why our irrigation schemes in Mysore should be considered from all aspects.

In the first place on the Mysore plateau irrigation water seems certain to be more expensive than in most other parts of India. In the second place there are few other parts of this great sub-continent where soil conditions vary so greatly even within comparatively short ranges of distance. I am led to believe that irrigation engineers may at times forget the fact that to make a success of an irrigation scheme the character or characters of the soil to be irrigated is of as great importance as the ease and cheapness with which water can be supplied. I may be mistaken but I feel that at times engineers may allow the attractiveness of a scheme from an irrigation standpoint to obscure the equally important question, "Is the land after all worth being irrigated?" One hears medical men now and then speaking of an interesting case or a beautiful operation with very little consideration for the patient and I am at times led to suspect that the engineer may be tempted occasionally to look upon an irrigation scheme in much the same light. There are perhaps parts of India where this attitude does not lead to serious consequences, for there are large stretches of country which any one can say will yield abundant returns from the application of water. Conditions in Mysore, however, do not warrant our treating irrigation schemes in such a simple fashion and I believe it is not unknown to those present that some of the projects developed in the past have yielded neither a satisfactory return to Government for the money invested nor an abundant one to the ryots who have made use of the water. It seems to me therefore—and I make the suggestion with considerable diffidence in the present company—that before new schemes are taken up it would be well to study them from an agricultural as well as an irrigation aspect.

This view has, I am glad to say, been recently accepted by the Government of Mysore in connection with the Irwin Canal Scheme. As many of you may be aware, the survey of this area from an irrigation standpoint which has of course been completed is now being supplemented by a soil survey which is being conducted by Dr. B. Narasimha Iyengar, Agricultural Chemist. Dr. Narasimha Iyengar will, it is hoped, soon have three small survey parties working under him and will complete the field survey operation on the first thirty thousand acres to be irrigated within three months' time. Soil borings which are being taken at regular intervals under all the sluices will furnish total soil samples weighing about six tons which will furnish the material

for study of the physical and chemical properties of the soil, an investigation which has already commenced in the Departmental laboratories at Bangalore.

While the scientific data that are being collected in this way will undoubtedly be of very great assistance to Government in their important duty of deciding on the best way of utilizing the water which is being supplied to this area through the skill and industry of our Irrigation Department, it is, I believe, important to correlate it with geological knowledge of the area. Luckily our Geological Department has already made a thorough geological survey of this area and there should be no difficulty in linking up the information which we are gaining as to soils with that already obtained as to the associated and underlying rocks. To enable this to be done proposals have recently been submitted to Government for the association of a geological officer in the operations in the field.

But there are still other problems which must be kept in view among which one of the most important is the effect of irrigation on the health of this large tract. Those familiar with health conditions in our older channel tracts must look forward with a certain amount of misgiving to the changes that may be brought about in an area which is at present a comparatively healthy one. I would not presume to suggest measures that should be taken to guard against this serious contingency. Most fortunately, it seems to me, the recent arrival of Mr. Mieldazis, Sanitary Engineer on the staff of Rockefeller Foundation for service in Mysore, has placed at our disposal technical knowledge which should be invaluable in this connection.

The recent inauguration of co-operative activity in the development of the most important single irrigation scheme that has ever been attempted in Mysore is a happy augury for the future. If it leads to the valuable results which I think we may safely anticipate it will point the way to a much more rational investigation of our irrigation problems than has been pursued in the past. With a commodity which from the standpoint of Mysore agriculture is so expensive and precious as irrigation water, with soil conditions which vary so greatly as they do in this State and with dangers to health which must accompany extensive changes from dry to wet cultivation, is it too much to expect that all the technical knowledge and skill

at the service of the State will be brought to bear on the consideration of important irrigation schemes ?

I have not touched upon the important economic problems connected with the utilization of irrigation water under the Irwin Canal which have been so ably discussed by Sir Alfred Chatterton in a note already familiar to you. Even were I competent to discuss these problems time would not permit me to do so. I should however like to emphasize the view that in the consideration of these important questions the health and prosperity of our agricultural population must occupy the centre of our attention.

I have earlier in my address expressed the view that tanks must, as far as we can see, continue indefinitely to be the main sources of irrigation water in Mysore. Government's far-sighted measures for the restoration and improvement of our tanks is a fitting recognition of this fact. I cannot help but feel, however, that due consideration has not yet been given to another question which is almost as important as tank restoration and improvement. Most, if not all, of you are as familiar as I with the fact that many, if not most, of our tanks even when in as good condition as is economically feasible, provide a very imperfect and unsatisfactory supply, so that we have every year the spectacle of valuable fields of sugarcane and paddy withering owing to the failure of water. The obvious, if still imperfect, remedy for this state of affairs is the provision of subsidiary wells in the irrigated areas. While this must remain largely a question for private initiative there are two obstacles which, I fear, cannot be overcome without the active intervention of Government. One of these is the inertia of the agriculturists themselves so tersely expressed in the words 'Rudi illa' (it is not the custom). The other consists of the technical difficulties frequently experienced in the sinking of wells. I personally feel that if a small fraction of the money now being devoted to the improvement and extension of irrigation works of all kinds could be diverted to propaganda and the provision of technical advice and equipment for the sinking of wells it would yield returns of immense importance to Mysore agriculture. This tentative suggestion would, if approved, involve the training and employment of a special class of well engineers. To the irrigation engineer who has been associated with works involving the expenditure of many lakhs or even crores of rupees, this type of activity may possibly not seem

particularly attractive. I am, by no means, sure, however, that a steady campaign in this direction would not lead to as beneficial results as some of the work that is now being attempted in connection with the extension and improvement of irrigation in Mysore.

I have upto the present considered some of the relations of the civil engineer to agricultural development. There are, however, other branches of engineering which, I feel sure, are destined to play an important role in the advancement of our most important industry. Of the introduction of electrical power into our agricultural operations I shall say nothing except that it seems certain it will become an increasingly important factor in agricultural development.

I should like however to refer to the contributions that the mechanical engineer can and should make towards agricultural improvement. As you are no doubt aware the Mysore Agricultural Department, as in fact almost every agricultural department in India, has been engaged for many years in testing various types of improved implements. The chief emphasis has been placed upon the plough, because it is the most important cultivation implement the ryot uses and because the indigenous plough is relatively much less efficient than most of the other indigenous implements. In addition to the very large number of plough types that have been imported from abroad numerous attempts have been made in India to design ploughs adapted to local conditions. The attempts at design have, for the most part, been made either by agricultural officers who have had little, if any, engineering training or by engineers who are equally ignorant about agriculture. The Royal Commission on Agriculture in their report emphasize the necessity of employing for the work of designing implements men who are expert mechanical engineers with a thorough practical knowledge of agriculture. To provide men of this type requires both time and money. Of these the latter seems to be at present in Mysore the more important limiting factor, for after all if money is not available for the training of such men and for the utilization of their services after they are trained the time factor ceases to have practical significance.

The need in Mysore is undoubtedly urgent. We are, it is true, introducing improved ploughs in this State at a more rapid rate per head of agricultural population and per acre of cultivated area than

in any other part of India. However the ploughs we are introducing are still but imperfectly adapted to our needs in many ways. I have not the time to go into this most interesting and important question in any detail but I may say that we are still far from knowing just what are the most suitable types and sizes of ploughs to meet the requirements of our varying soils and our almost equally varying work-bullocks. What is of almost equal importance from the standpoint of the ryot is the design of the implements and the choice of materials with reference to wear. When I tell you that where improved ploughs are used on our typical red soils the main wearing parts, such as shares, slades and mould boards, wear out at least four times as rapidly as do similar parts used in Canada, you will see how important this question is. The cost of replacements is undoubtedly one of the main factors preventing the rapid introduction of ploughs in Mysore.

The questions assume a greatly increased importance from recent developments in the State. I have felt for some time that village panchayats should be utilized much more extensively than they have been in the past, in connection with the introduction of improved implements. I have recently discussed the question with my esteemed friend the Revenue Commissioner and he has very kindly agreed to co-operate in an attempt to introduce improved ploughs on a large scale through village panchayats. If this scheme is the success I anticipate, we shall see a very rapid increase in the use of improved implements during the next few years. It is rather hazardous to attempt an estimate of our future requirements of ploughs and other improved implements but I would venture to predict that this State will, in the course of time, be able to absorb 50,000 improved ploughs per annum. At present, very considerable numbers of these implements are being imported from outside India and practically all of them come from outside the State. Most of the larger types of ploughs being used in the State are, it is true, being manufactured largely from Bhadravati iron but what few ploughs are actually being made in the State are the hand-work of certain progressive and skilful blacksmiths who are using what material they can obtain cheaply to make copies of the ploughs imported from outside.

There is, I believe, good evidence that certain grades of Bhadravati iron are very suitable for the manufacture of essential plough parts but the whole question has not yet received the attention it deserves.

The initiative will, I believe, have to come from Government departments and I should like to look forward to close co-operation between the technical experts of the Iron Works, of the Industries and Commerce Department and of the Agricultural Department in the work of designing and testing implements and in the utilization of Mysore iron in their manufacture. If we are able to achieve this co-operation the time should not be far distant when our trained mechanical engineers will find a profitable opening for the utilization of their training and skill. It is true that the manufacture of agricultural implements is specialized business but that should be no reason why we should depend indefinitely upon manufacturers outside Mysore for our supplies. There are, in my opinion, few ways in which the engineering profession could be of more service to the State than in turning their attention to the manufacture of improved agricultural implements.

This address is a plea for co-operation. The day of the all-round expert even in the comparatively restricted field of agriculture has gone by. We need the help of engineers on every side in the improvement of our agricultural conditions. On the other hand where your schemes touch directly the agriculture of the State they will gain much in soundness and clarity from the advice and criticism of men who have made the study of agriculture and agricultural conditions their life's work. There is a type of individual who, whether from jealousy or arrogance or independence or excessive shyness and modesty, cannot work with others. When such an individual combines with any of these qualities genius, he may accomplish much in the way of noble and beneficent discoveries. Unfortunately the supply of geniuses in any country is small and certainly Government service does not afford congenial ground for their development. Under the circumstances that now exist and are likely to exist in the future I am convinced that a closer co-ordination of effort towards the economic development of Mysore is necessary if we are to obtain anything like the maximum results from the funds at our disposal.

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## Use of Tractors in Eradicating *Hariyali* Grass on Black Cotton Soil.

BY

**S. H. Bennur, L.Ag.,**

*Farm Manager, Babbur Farm.*

The problem of the eradication of hariyali on the black cotton soil is an important one. Hariyali is a serious pest in these soils, reducing, as it does, the cotton yield considerably; and if not rooted out in time, it over-runs the whole field and makes the land quite unfit to carry any crop. As regards the destruction of hariyali on black cotton soil, the farmers have their fields dug up about one foot deep in the hot weather at great cost and trouble. Heavy iron mould board ploughs require 4 to 6 pairs of bullocks to do this hot weather ploughing; but though quicker than hand digging this method requires considerable co-operation on the part of farmers. But by ploughing with a suitable tractor it has been demonstrated that a good job can be done and cheaply also.

Three methods of eradicating hariyali were tried on the Babbur Farm during the end of March and the first week of April 1929.

### Tractor ploughing :—

1. Messrs. Volkart Bros., Bangalore Branch, demonstrated on the dry lands of the Babbur farm the working of the 15-30 B.H.P. McCormick Deering Tractor with a Brush Braker plough to eradicate the hariyali grass which had practically over-run S. No. 165 of the farm. The nature of the soil is black cotton of a medium depth of about 3 ft. There was plenty of moisture below 6" of the surface soil, which did not allow the smooth working of the tractor. It had to be stopped every 5 minutes to remove the mud that clogged the wheels of the tractor. In spite of this handicap, it ploughed 4.1 acres per day, opening a furrow 1' 2" wide and one foot deep on an average. The cost worked out to Rs. 10-4-8 per acre excluding the pay of the driver and the depreciation charges on the outfit.

### 2. Ploughing with the Ransomes Gallows Plough :—

This was worked on the same land with 3 pairs of strong bullocks. In all 3½ acres were ploughed by this plough which opened furrows 10" broad with a depth of 8". The cost of ploughing works out to Rs. 8-2-6 per acre.

### 3. Hand digging :—

One gunta of similar land was dug to a depth of 10" the cost of which works out to Rs. 30 per acre.

The effect of these three methods on the destruction of hariyali in S. No. 165 is as noted below :—

#### *The tractor ploughed area.*—

1. There is hardly one per cent of hariyali although there was a rainfall of 5.4" during the month of May 1929. The standing crop is *sanhatti* (Cotton Selection 69). The crop is very good and promising.

#### 2. The area ploughed with the Gallows plough :—

About 10 to 15 % of hariyali grass is still seen growing. The standing crop is *sanhatti* (S. 69) and is equally good in growth.

3. In the hand dug portion, which is only one *gunta* in extent, there is practically no hariyali grass ; but the standing crop of *sanhatti* (S. 69) is not so luxuriant in growth as in Nos. 1 and 2. Since the plot is situated far off from the other 2 lots the difference in growth may be due to other causes.

The details of the expenses incurred in ploughing 11 1/5 acres of land by the tractor plough are shown below :—

|                                                                                          | Rs.        | A.       | P.       |
|------------------------------------------------------------------------------------------|------------|----------|----------|
| 25 tins of Kerosene oil .. .. .                                                          | 95         | 6        | 0        |
| "A" Oil 2 gallons .. .. .                                                                | 5          | 12       | 0        |
| "C" Oil 2 gallons .. .. .                                                                | 5          | 0        | 0        |
| Grease 8 lbs. .. .. .                                                                    | 2          | 12       | 0        |
| Petrol 2 gallons .. .. .                                                                 | 2          | 14       | 0        |
| Labour to collect the grass behind the plough and expose<br>the same to sunahine .. .. . | 3          | 12       | 0        |
| <b>TOTAL</b> ...                                                                         | <b>115</b> | <b>4</b> | <b>0</b> |

Time taken is 41 hours in 10 days. Therefore the cost per acre of ploughing is Rs. 10-4-0.

## SELECTIONS.

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### Large-Scale Co-operation in America.

Two million farmers are organized into 12,000 associations in the United States for the purpose of marketing their products or buying their supplies, or doing both, on a co-operative basis, according to the United States Department of Agriculture. Last year they sold collectively farm products to the value of nearly £400,000,000 and they purchased farm supplies to the value of about half a million dollars.—*Agricultural Gazette of New South Wales*, Vol. XL, No. 10.

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### World Production of Peanuts (Groundnuts).

Peanut crops in the 12 countries producing more than 100,000,000 pounds annually increased by over a billion and a half pounds during 1928, as compared with 1927, according to estimates of the International Institute of Agriculture. The increase in India alone exceeded a billion pounds, owing to the increase of 600,000 acres in the harvested area in 1928. World production estimates for the leading countries based on figures of the International Institute of Agriculture, United States Department of Agriculture and reports from foreign offices, follow:—

#### THE ESTIMATED WORLD PRODUCTION OF PEANUTS.

| Country                        | Year | Pounds        |
|--------------------------------|------|---------------|
| ASIA—                          |      |               |
| British India .. ..            | 1928 | 6,776,000,000 |
| China .. ..                    | 1929 | 1,275,000,000 |
| Formosa .. ..                  | 1928 | 66,900,000    |
| French Indo-China .. ..        | 1928 | 16,600,000    |
| Japan .. ..                    | 1927 | 24,800,000    |
| Kwantung .. ..                 | 1928 | 135,400,000   |
| Java and Madura .. ..          | 1928 | 358,900,000   |
| AFRICA—                        |      |               |
| French Equatorial Africa .. .. | 1927 | 192,300,000   |

| Country                          | Year | Pounds        |
|----------------------------------|------|---------------|
| French West Africa—              |      |               |
| French Guinea .. .. .            | 1928 | 6,000,000     |
| Upper Volta .. .. .              | 1928 | 100,900,000   |
| Niger Territory .. .. .          | 1928 | 33,000,000    |
| Senegal .. .. .                  | 1928 | 1,080,000,000 |
| French Sudan .. .. .             | 1927 | 123,500,000   |
| Egypt .. .. .                    | 1928 | 29,300,000    |
| Gambia .. .. .                   | 1928 | 166,700,000   |
| Portuguese Guinea .. .. .        | 1926 | 33,000,000    |
| Nigeria .. .. .                  | 1928 | 231,000,000   |
| Anglo-Egyptian Sudan .. .. .     | 1928 | 38,000,000    |
| Madagascar .. .. .               | 1925 | 53,000,000    |
| Tanganyika .. .. .               | 1928 | 36,000,000    |
| Union of South Africa .. .. .    | 1929 | 24,200,000    |
| SOUTH AMERICA: Argentina .. .. . | 1917 | 143,000,000   |
| EUROPE: Spain .. .. .            | 1928 | 60,000,000    |
| NORTH AMERICA—                   |      |               |
| Mexico .. .. .                   | 1928 | 16,500,000    |
| United States—                   |      |               |
| Nuts gathered .. .. .            | 1929 | 930,700,000   |
| Nuts total .. .. .               | 1929 | 1,360,000,000 |

—Commerce Report, January 27, 1930, No. 4.

### Cactus in Madagascar.

Writing in *Science* (July 12, 1929), C. F. Swingle calls attention to the interesting history of the prickly pear (*Opuntia dillenii* and *O. ficus-Indica*) introduced into Madagascar about two centuries ago. The plants thrive in the more fertile regions and became a pest. In the arid parts of the island they became the most important economic plant, furnishing not only food and drink for man and beast, but impenetrable barricades around fields and villages. Unfortunately cochineal insects were introduced and they have exterminated the cacti, a serious calamity to the Antandroy tribe. An effort is being made to use cochineal resistant species to replace the susceptible species that have been eradicated. (*Journal of Heredity*).—*The Madras Agricultural Journal*, Vol. XVIII, No. 2.

### Cane Ripening Experiments.

In an article which appears in the *Hawaiian Planters' Record*, Vol. XXXIII, No. 2, Messrs. J. A. Verret, A. J. Mangelsdorf and C. G. Lennox describe a cane ripening experiment carried out by the Honolulu Plantation Company with the co-operation of the chemistry, sugar technology and agricultural departments, Hawaii Sugar Station. The following summary is given:—

“The experiment was located on a field situated at an elevation of about 250 feet, whose soil consisted of a red silty clay loam of fair depth. A series of ten plots distributed uniformly over the field was harvested at the beginning of the ripening period, twenty-five days after the final irrigation. A second series was harvested three weeks later, and so on. In all, seven series covering a period of four months were harvested.

At each harvesting, the following determinations were made for each plot: cane yield, Brix, polarization and purity of the crusher juice. From these the quality ratio, yield of tons of sugar per acre and tons of sugar per acre per month were calculated. Per cent glucose,  $P_2O_5$  and  $K_2O$  in juice and per cent fibre in cane were also determined. Soil samples from the first, second and third-foot depths were also taken for each plot and their moisture and nitrate nitrogen contents determined.

The trends of the different values were as follows:—

1. Yield of cane per acre increased slightly up to 44 days and remained practically constant thereafter.
2. Brix increased at first rather rapidly and thereafter more slowly.
3. Polarization increased rapidly up to 65 days after which it declined gradually.
4. Purity improved up to 65 days thereafter holding its level fairly constant to 90 days, when it began to decline.
5. Yield of sugar per acre increased rapidly up to 65 days, and more slowly up to 90 days after which it declined.
6. Yield of sugar per acre per month increased rapidly up to 65 days after which it declined at first gradually, then rapidly.
7. Per cent moisture in cane declined slightly and gradually.
8. Per cent fibre in cane increased as ripening progressed, somewhat erratically, however, due probably to experimental error.
9. Soil moisture declined to the wilting point, then rose again as a result of showers and finally declined once more to the wilting point.
10. Nitrate nitrogen in the soil first declined and then increased.

11.  $P_2O_5$  and  $K_2O$  in the juice showed a slight and gradual increase, associated possibly with the slight increase in concentration of cell sap due to drying out.

It was concluded that under the conditions of the experiment the greatest returns in terms of sugar per acre per month are realized when the cane is harvested within 60 to 90 days after the final irrigation. Over-ripening may result in loss of sugar, loss of growing time for the next crop and injury to ratoons."—*Tropical Agriculture*, Vol. VI, No. 8.

### The Selection of Feeds.

BY D. D. GILES.

To what extent are we interested in the selection of gross feeds? One often hears a certain food substance acclaimed as the best one that exists. It is my contention that there is no best feed or no best combination of feeds. I venture further to say that there is no one balanced feed.

The well-informed feeder has long ago learned that it is not grain or hay as such that should attract his praise. He has learned that the gross grain or hay is not worth a single thing to his livestock. It is the specific nutrients and life-promoting elements that are contained in that grain and hay that will prove of benefit to his animals and will consequently reap a personal reward for him. Until a feeder learns to look below the surface he will be hoping to get results instead of actually getting them. Which offers the surest route to success, the path of luck or the path of knowledge and understanding? In our newer knowledge of nutrition we are still just beginning to understand the fundamental demands of the animal, but surely we can clear our conscience enough to apply rightly those few facts that we do know.

Before one can select a feed with any degree of correctness he must clearly have in mind just what is expected to come from that feed. Will the feed be fed simply to maintain animals? Will it be fed for production of energy that will in turn be transferred into work, or milk production? Or will it be fed to fatten animals? Each of these requires a different type and combination of nutrients. If the feed or combination of feeds are to be fed for maintenance they must supply energy, vitamins, minerals and protein.

The energy must be given the animal to furnish fuel for body activities such as respiration, circulation, secretion, excretion and absorption and assimilation. In addition enough energy must be supplied

to care for the loss from voluntary movements as walking, mastication, defecation, etc. It is essential that the energy be supplied in feeds that the energy can be extracted from with a minimum of activity by the animal. If there are only 1,000 calories of usable energy in a feed, and the animal expends that much energy in extracting it, he does not benefit any from the feed he has consumed. The feeder must calculate the feed value from a net basis rather than from the gross.

If good pasture is not available, vitamins become a limiting factor, and one should realize that the feeds purchased must supply vitamins A, C, E, F and G. Vitamin D is also a limiting factor but this is supplied in ample amounts by exposure to direct sun rays. When this is so available, it would be folly to purchase it in sacks or bottles.

*Minerals.*—A chain is no stronger than its weakest link and a feed is surely no better than its worst deficiency. Numerous minerals are required for maintenance of livestock; but phosphorus, calcium, sodium, chlorine and iodine are the ones in which our common feeds are most often deficient. The amounts of these in feeds vary with the species of feed and the type of soil on which the feeds were grown. In buying or raising feeds one would do well to select his feeds so that these minerals will be supplied.

*Protein.*—It is true that the animal being merely maintained requires a minimum of minerals and also a very small amount of proteins. But even though only a minor amount is needed, a major harm will be done if the proper amount is not supplied. And just as quantity and quality of minerals are demanded, so amount and kind of proteins must be considered. There are possibly as many different kinds of proteins or amino-acids as there are minerals, but according to our present knowledge only five of these are essential for the animals' well-being. These are tyrosine, cystine, tryptophan, lysine, histidine and arginine. All of these must be supplied, and if one of them is missing no benefit will be derived from increasing the amount of the others. Our knowledge of amino-acids is very limited at the present time. But valuable work is being done in an endeavour to learn in which feeds each amino-acid is found. Until that information is obtained, we will have to rely upon chance alone as to whether the essential amino-acids are supplied. This explains why variety of ration is so often stressed. Beside quality of proteins one must consider the amount of protein needed. Of course the mature animal needs only enough protein to repair broken-down tissues, and if a milk cow—she must have sufficient protein to produce

the milk. Protein is also essential in the ration in that it increases the digestibility of the other nutrients.

*Carbohydrates.*—Carbohydrates are composed of starches and sugars. Their chief function is to produce energy for the body. It is true that an excess of protein is given an animal and not enough of other energy supply foods are given, then the animal has the ability to split off the carbohydrate radicle of the protein and produce energy from it. But in doing so quite a number of waste products are left behind that prove injurious to the animal. So the animal is dependent upon carbohydrates for its chief source of energy. In addition to energy, carbohydrates are essential to the animal's well-being in that they aid in the digestion of fats. When fats are metabolized in the absence of carbohydrates, acetone bodies accumulate in the body; and the animal goes into a state of coma and suffers from acidosis.

*Fats.*—Although fats are given animals chiefly because they are concentrated forms of energy-giving products, their functions are chiefly the same as those of carbohydrates. But fats also play another rôle in the cycle of digestion and assimilation. The metabolism of minerals is dependent upon the activity of the para-thyroid gland and if fats are not supplied the para-thyroids lose their power to metabolize the minerals.

So if we are to sum up the selection of a ration for stock, we should consider proteins, carbohydrates, fats, minerals and vitamins. These must be supplied and they must be in the right proportions. Then the cost, availability, palatability must also enter into the selection. Know your feeds, know your animals, and you will get better results from less feed.—*Veterinary Medicine*, Vol. XXIV, No. 12.

### **My Experiences of a Modern Farm Tractor.**

BY AMANAT ALI HABIBULLAH, DIP. AGR.,

*Malguzar and Landlord, Kusamkot, Berar.*

The following article gives an account of the writer's own experience with a motor tractor, used partly for cultivation and partly for cotton ginning, in the black cotton soil tract of Berar. The allowances which should be made for depreciation, repairs and loss of time through breakdowns under Indian conditions are still a matter of opinion and will naturally vary with the circumstances under which the machine is used. Estimates of the useful working life of tractor are equally varied.—Editor, *Agri. Jn. of India*.

Many attempts have been made in the past by different contributors, show organizers and agricultural firms in India to give some figures and calculations as to working cost and other details for ploughing with

motor tractors, but many, if not all, of them have based their remarks on the results of short trials and demonstrations lasting only a few hours or, at the most, a few days, when every part of the machinery under trials is put in excellent order and the best and expert attention is given to it while being demonstrated. Thus anything judged from such trials of short duration and any conclusion drawn, is bound to be erroneous and misleading. I, therefore, propose to place before the landed aristocracy and the rural public some results of my experience with some modern agricultural machinery.

I have about 800 acres of land under direct cultivation. A "McCormick Deering" or commonly called an International Tractor (15-30 H.P.), has been working on my farm for the last four years. It is being used for the following jobs:—

(1) From the beginning of December till the end of March every year, for running a small ginning factory consisting of 8 gins. (The actual working days are about 75 days.)

(2) From the first week of April till the break of the monsoon for ploughing.

(3) In certain years, from the end of the rainy season, say, from the middle of September for a month or so, for discing land prior to rabi sowing. I shall take each item separately.

#### GINNING FACTORY.

The factory consists of 8 gins (Platt Bros. single roller "McCarthy" cotton gin). Each gin is worked separately and, if applied power direct, requires about  $2\frac{1}{2}$  H.P. But as intermediate gearing or second motion shaft is used in order to work more than one gin some extra power is consumed, which in practice is found to be  $\frac{1}{2}$  H.P. per gin. Therefore 8 gins require 24 H.P. Mine is a 30-H.P. motor and therefore it pulls the load very easily. It is always safe and advisable to work an engine at a lighter load as it saves so much wear and tear.

The factory is worked for ten hours daily (in two periods of five hours each with an interval of an hour). This gives time to factory labourers to take food and have some rest. In the meantime, the driver looks to lubrication, cleaning, etc.

The running cost comes to about (i) Rs. 43-14-7 for the tractor and (ii) Rs. 33-7-2 for the factory (8 gins) as follows:—

TABLE I.

| WORKING COST OF TRACTOR PER DAY. |                                                |       | Rs. A. P. |    |   |
|----------------------------------|------------------------------------------------|-------|-----------|----|---|
| 1.                               | Driver at Rs. 60 per month                     | .. .. | 2         | 0  | 0 |
| 2.                               | Cleaner at Rs. 15 per month                    | .. .. | 0         | 8  | 0 |
| 3.                               | Kerosene, 8 tins (4 gallons each)              | .. .. | 24        | 0  | 0 |
| 4.                               | Petrol .. ..                                   | .. .. | 0         | 3  | 0 |
| 5.                               | Mobiloil, 1 gallon                             | .. .. | 3         | 0  | 0 |
| 6.                               | Gear oil, $\frac{1}{4}$ gallon approximately   | .. .. | 0         | 8  | 0 |
| 7.                               | Grease and cotton waste                        | .. .. | 0         | 2  | 0 |
| 8.                               | Interest (Table III, <i>b</i> , 2)             | .. .. | 3         | 9  | 7 |
| 9.                               | Depreciation (Table III, <i>c</i> , 2)         | .. .. | 6         | 10 | 8 |
| 10.                              | Repairs and renewals (Table III, <i>d</i> , 2) | .. .. | 3         | 5  | 4 |
| TOTAL COST PER DAY               |                                                |       | 43        | 14 | 7 |

TABLE II.

| WORKING COST OF FACTORY PER DAY. |                                                                                                        |       | Rs. A. P. |    |   |
|----------------------------------|--------------------------------------------------------------------------------------------------------|-------|-----------|----|---|
| 1.                               | Fitter at Rs. 90 per month                                                                             | .. .. | 3         | 0  | 0 |
| 2.                               | Oilman at Rs. 20 per month                                                                             | .. .. | 0         | 10 | 6 |
| 3.                               | Nine feeder women (one per gin and one extra)                                                          | .. .. | 2         | 13 | 0 |
| 4.                               | Three kapas carriers at As. 8                                                                          | .. .. | 1         | 8  | 0 |
| 5.                               | Two men for filling and pressing bags                                                                  | .. .. | 1         | 0  | 0 |
| 6.                               | Two women for removing cotton seed                                                                     | .. .. | 0         | 10 | 0 |
| 7.                               | Mochi at Rs. 20 per month                                                                              | .. .. | 0         | 10 | 6 |
| 8.                               | Ginning oil, 2 gallons                                                                                 | .. .. | 2         | 0  | 0 |
| 9.                               | Breakage and repairs, spare parts, roller washers, beltings, etc., as shown in Table IV, <i>d</i> , 2. | .. .. | 6         | 0  | 0 |
| 10.                              | Interest on the outlay (Table IV, <i>b</i> , 2)                                                        | .. .. | 7         | 3  | 2 |
| 11.                              | Depreciation (Table IV, <i>c</i> , 2)                                                                  | .. .. | 8         | 0  | 0 |
| TOTAL COST PER DAY               |                                                                                                        |       | 33        | 7  | 2 |
| Combined cost of (i) and (ii)    |                                                                                                        |       | 77        | 5  | 9 |

TABLE III.

## INTEREST, DEPRECIATION AND SPARE FOR TRACTOR OUTFIT.

- (a) 1. Estimated to cost about Rs. 6,000.  
 2. Maximum working period (on my estate)—5 months.  
 3. Average working period (ploughing on a farm or with a private owner)— $3\frac{1}{2}$  months.

|     |                                                                                                                                          | Rs.   | A. | P. |
|-----|------------------------------------------------------------------------------------------------------------------------------------------|-------|----|----|
| (b) | 1. Interest on Rs. 6,000 at the rate of Rs. 9 per cent per annum (the whole amount of interest is chargeable on 5 months or 150 days) .. | 540   | 0  | 0  |
|     | 2. Interest per day at the above rate ..                                                                                                 | 3     | 9  | 7  |
|     | 3. Interest per acre of land ploughed (counting 5 acres a day) ..                                                                        | 0     | 11 | 6  |
| (c) | Life of tractor is taken as six years—                                                                                                   |       |    |    |
|     | 1. The depreciation value comes to about 16.66 per cent per annum (chargeable on 5 months or 150 days actually worked) ..                | 1,000 | 0  | 0  |
|     | 2. Depreciation per day ..                                                                                                               | 6     | 10 | 8  |
|     | 3. Depreciation per acre (at 5 acres a day) ..                                                                                           | 1     | 5  | 4  |
| (d) | 1. Cost of repairs and spare parts as actually found (average of last four years) ..                                                     | 500   | 0  | 0  |
|     | 2. Do. per day ..                                                                                                                        | 3     | 5  | 4  |
|     | 3. Do. per acre ..                                                                                                                       | 0     | 10 | 8  |

TABLE IV.

## INTEREST, DEPRECIATION AND SPARE FOR FACTORY ESTABLISHMENT.

|     |                                                                                                                                                     | Rs.   | A. | P. |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|----|
| (a) | 1. Estimated to cost about Rs. 6,000 (including building, construction work, erection, etc.) ..                                                     | 6,000 | 0  | 0  |
| (b) | 1. Interest on Rs. 6,000 at Rs. 9 per cent per annum ..                                                                                             | 540   | 0  | 0  |
|     | 2. As the working days are only 75, this amount of interest, <i>i.e.</i> , Rs. 540 is to be charged on 75 days and therefore it comes per day to .. | 7     | 3  |    |
| (c) | 1. Depreciation at 10 per cent (to be charged on 75 days only) ..                                                                                   | 600   | 0  |    |
|     | 2. Do. per day ..                                                                                                                                   | 8     | 0  |    |
| (d) | 1. Cost of repairs and spare parts for the season (75 days) ..                                                                                      | 450   | 0  |    |
|     | 2. Do. per day ..                                                                                                                                   | 6     | 0  |    |

The outturn of clean cotton per gin comes to about 5 maunds or 410 lbs. per day (of 10 hours). Ginning charges are Rs. 2½ per maund which gives an income of Rs. 12-8-0 per gin per day or Rs. 100 for the whole factory per day.

The net income, therefore, comes to Rs. 22-10-3 per day.

## PLOWING.

Ploughing is done in summer only which in this tract (Melghat taluk of the Amraoti district) cannot be commenced earlier than April as the cotton crop occupies a longer period—the last cotton picking is done in March—and as the wheat is also harvested in that month. The working cost of ploughing by tractor per day is shown in Table V.

TABLE V.

|                                  |                                                                                    |    |    | Rs. | A. | P. |
|----------------------------------|------------------------------------------------------------------------------------|----|----|-----|----|----|
| 1.                               | Driver's pay at Rs. 60                                                             | .. | .. | 2   | 0  | 0  |
| 2.                               | Cleaner at Rs. 15 per month                                                        | .. | .. | 0   | 8  | 0  |
| 3.                               | Kerosene (5 tins for 5 acres in 10 hours or 2 gallons per hour)                    | .. | .. | 15  | 0  | 0  |
| 4.                               | Petrol, $\frac{1}{4}$ gallon                                                       | .. | .. | 0   | 6  | 0  |
| 5.                               | Mobiloil, 1 gallon                                                                 | .. | .. | 3   | 0  | 0  |
| 6.                               | Gear oil, $\frac{1}{2}$ gallon                                                     | .. | .. | 1   | 0  | 0  |
| 7.                               | Grease and cotton waste                                                            | .. | .. | 0   | 4  | 0  |
| 8.                               | One pair of bullocks, a cart and a driver or waterman for fetching water from well | .. | .. | 2   | 0  | 0  |
| 9.                               | Interest (Table III, <i>b</i> , 2)                                                 | .. | .. | 3   | 9  | 7  |
| 10.                              | Depreciation (Table III, <i>c</i> , 2)                                             | .. | .. | 6   | 10 | 8  |
| 11.                              | Repairs and renewals (Table III, <i>d</i> , 2)                                     | .. | .. | 3   | 5  | 4  |
| TOTAL COST OF PLOWING PER DAY .. |                                                                                    |    |    | 37  | 11 | 7  |

From the above Table, we find that the total cost for ploughing per day is Rs. 37-11-7 which comes to about Rs. 7-8-8 per acre (on the assumption of ploughing five acres a day). But this is only true for a particular day or for a short period, say, a week or so. In actual practice we find that—

(i) Continuous work for the whole week is never done as the driver must have at least a day in a week for rest, marketing and looking thoroughly over his machine to see that everything is in perfect order and for doing petty repairs, etc.

(ii) Similarly continuous work for the whole month is not done as (a) sometimes the driver may be required to go to town to get some repairs done there in a workshop or at a blacksmith's, and so on, or (b) at times he might be compelled to wait for a spare part (having broken one by accident or any other cause) which has been ordered from Bombay. If unfortunately the place where the tractor is working is at a long

distance from a railway or post office, as in my case, considerable time is lost in transit, and therefore taking the whole month's average it is not possible to plough more than 100 acres a month.

#### DISCING.

The working cost per day is nearly the same as for ploughing but the day's work is greater. On an average 8—10 acres are disced. The discing charges, therefore, come to nearly half that of ploughing.

Since the soil in my tract is stiff black, very big clods come up after ploughing in the hot weather. The disc harrow, therefore, is not a good implement for working as a clod crusher after ploughing in the black cotton area. I use it only when the soil is moistened after a good shower of rain or, at the end of the rains, for the preparation of rabi land.

#### CONCLUSIONS.

1. An International 15-30 H.P. tractor can be used for field work and belt (or stationary) work as well.

2. It can drive eight gins quite easily. The total cost per day of 10 hours for both tractor and factory (8 gins) comes to Rs. 77-5-9.

3. The outturn of clean cotton per gin when worked with the tractor is 5 maunds or 410 lbs. for 10 hours.

4. Taking a day's average, it can plough about 5 acres of land (black cotton soil) in summer. The working cost per acre comes to Rs. 7-8-8.

5. In the black cotton soil tract a power disc harrow cannot be used for breaking clods after the land is ploughed.

6. The tractor can easily disc about 8-10 acres of land after a good shower of rain (the only idea being that there should be enough moisture in the soil). The working cost comes to about Rs. 4 per acre.—*The Agricultural Journal of India*, Vol. XXV, Part I.

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#### Green Manuring with Particular Reference to Cocoanuts.

*The Practice of Green Manuring.*—Green manuring is an ancient agricultural practice which has played an important part in both western and eastern agriculture. It is recorded that it has been carried on China for over 3,000 years and in Europe for at least 2,000 years. Green manuring is now widely practised, and in the tropics it has become, within comparatively recent years, an established

agricultural operation on many tea and rubber estates. It has only recently been undertaken in a systematic manner on cocoanut estates. In the Dutch East Indies and the Philippines it is almost universally practised on European and American-owned plantations and is becoming increasingly popular on native owned properties. In Malaya, it is extensively carried out, but in Ceylon the practice is far from being general. Individual estates, however, are carrying out extremely useful work on the subject and some of this work I have been privileged to see for myself. In general, all cocoanut estates on which green manuring has been adopted have reported very favourably on the results obtained. Neglected properties for years under grass are being brought into condition by cultivation and green manuring. The value of green manuring, happily enough, is becoming more understood and the practice shows signs of spreading. It will be a good day for Ceylon's cocoanut industry when all cocoanut estates have adopted some rational system of green manuring. The rubber industry affords an instance of how a practice which is of so great agricultural value in tropical countries can become widely adopted. In connection with experimental work with green manuring of cocoanuts, it may interest cocoanut planters to learn that one of the chief lines of research to be undertaken at the new Wariyopola Experiment Station of the Department of Agriculture is the study of green manuring of cocoanuts in all its aspects.

*What is Green Manuring?*—In this paper the term "green manure" will include "cover crops". The distinction between them, however, should be pointed out. A cover crop is planted for the purpose of protecting and covering the soil. When it is turned into soil it becomes manure. A crop which is solely used for turning into the soil is a green manure crop, so that a cover crop can be used as a green manure crop but not all green manure crops as cover crops.

Green manuring is the practice of incorporating into the soil undecomposed plant material with the object of increasing soil fertility. The green material may be grown *in situ* or brought from outside. It is commonly believed that only leguminous plants are beneficial as green manures, but this is not so. Non-leguminous plants are useful for green manuring provided they are brought from outside and not grown on the area which is to be green-manured. It may be useful to allow non-leguminous plants to grow at site, *e.g.*, as covers on hilly ground, and to turn them in later, but this practice is not to be generally recommended. Leguminous plants are of value as green manures because of the large amounts of nitrogen they fix in the soil through the nodules on their roots. These nodules contain bacteria which carry on the

work of nitrogen fixation, the energy for the process being derived from the carbo-hydrate material supplied by the plant. When, therefore, leguminous plants are grown on a soil, they enrich the nitrogen content of the latter, even if the leafy material is not turned in. If the latter is turned in, the soil is then markedly enriched, both in nitrogen and organic matter.

*The Advantages and Importance of and Need for Green Manuring in General and Green Manuring of Cocoanuts in Particular :—*

The advantages of a green manure crop are as follows :— (1) If the green manure is a cover crop, it prevents the loss of valuable surface soil from hilly and undulating land caused by the heavy rainfall of tropics. The covers also take up the plant-fertilizing constituents contained in the surface layers of soil which would otherwise be leached out.

(2) It protects the soil against the beating action of the rain and the excessive heat of the sun. This in the tropics is a matter of great importance. Tropical rains are so heavy that the soil surface is often "capped" and made impervious to water. As a result, excessive losses of moisture from the soil surface take place through capillary action when dry weather sets in. When rain subsequently falls on the "capped" surface, the greater part of it flows over and is not absorbed by the soil. Green manures keep the soil open by their root action and hence rain water is absorbed much more readily on green-manured soils. The shade afforded by cover crops also prevents direct loss of moisture from the soil surface.

(3) Ploughing in green manures adds valuable organic matter to the soil ; on decomposition the material forms humus. It is well known that Ceylon soils in general and cocoanut soils in particular are very deficient in organic matter. Green manure crops give from 2 to 10 tons of green material per acre and this will assist to an appreciable extent in increasing the content of soil humus. Humus has many properties. Among others (1) it absorbs water and the mineral constituents of the soil and regulates the supply of these and of the nitrogenous substances absorbed by plant roots ; (2) it improves the texture of tilth of soil breaking up heavy soils and binding together light soils and rendering them better able to withstand drought ; (3) it is the storehouse of the nitrogen of soils ; (4) on it depends the activity and number of the micro-organisms which are the life of the soil. These micro-organisms fix the free nitrogen of the soil, obtaining their energy for so doing from the soil organic matter, and the carbon dioxide formed in the process makes

available to the crop some portion of the mineral constituents of the soil.

(4) Green manures reduce weeding costs, especially on new clearings. Cover crops when firmly established smother out weeds. Weeding is a big item on many tropical estates, and in cocoanuts a saving effected in the weeding bill should materially affect the cost of production.

(5) By green manuring, the surface soil is supplied in a quickly available form with plant food constituents obtained by the green manure crop from the soil and sub-soil.

(6) By the growth of green manures the aeration of the soil is improved and the roots of the main crop are enabled to penetrate deeper into the sub-soil.

(7) The leafy material of many green manure plants can serve as a useful fodder.

(8) The amount of nitrogen supplied to the soil by green manuring with leguminous crops can be considerable. Reckoning on an average crop of, say, 4 tons of green material per acre per annum, containing on an average 6 per cent of nitrogen, the amount of nitrogen by which the soil is enriched will be at least 50 lbs. per acre. This is a conservative estimate as it does not take into account the amount of nitrogen contributed by the roots and nodules of a leguminous crop, but it is sufficient to show how much the nitrogen content of a soil can be improved by this means. Not all this nitrogen is available to the crop. Experiments in temperate countries have shown that if the availability of nitrate of soda is reckoned as 100, that of green manures is about 65. The greater portion of the remainder goes to form the nitrogen of the soil humus. The question has been raised as to whether the large amounts of nitrogen added to the soil by green manure would affect the yields of cocoanuts adversely. Of this there is little danger, for the amount of nitrogen available to the coconut crop from an average green manure crop would be about 35 lbs. per acre per annum, based on the figures quoted above. This can hardly be called an excessive dose of nitrogen. There is the further fact to be considered, *viz.*, that the leaves and branches of the coconut tree will take up a fair portion of the nitrogen supplied by green manures. It is essential, however, that on green-manured coconut estates potash and phosphoric acid be applied and preferably in larger quantities than those normally required by the coconut. Experiments are being carried out at Peradeniya to determine the increase in carbon and nitrogen of soils as a result of green manuring soils (a) *in situ*, (b) with crops brought from outside. Work

in other countries has shown that both the carbon and the nitrogen contents of soils can be very appreciably increased by green manuring. Non-leguminous creeping crops may be used as cover crops on hilly land where leguminous crops will not grow. But as these crops compete with the main crop for the soil moisture and fertilizing constituents and may therefore harm the latter temporarily, their use is not unreservedly recommended. Owing to the large amounts of nitrogen contributed by leguminous green manures, it may safely be stated that, on cocoanut estates where green manuring is systematically carried out, no harm will result by eliminating nitrogen, especially organic nitrogen from the manure mixture. The amount of organic matter supplied by organic nitrogenous manures in quantities used in manure mixtures is very insignificant. As nitrogen is the most expensive item of a manure mixture, the present manure bills can thereby be considerably reduced. Thus, of Rs. 30 per acre spent per annum on manuring cocoanut estates, the nitrogenous constituents cost about half, an expenditure on manuring can therefore be reduced by half. This amount can be utilized for the first few years for establishing green manures. Further, where green manuring is generally practised and good yields are obtained, even in periods of normal crop prices, any nitrogen added in manure mixtures should always be in mineral form.

To sum up : by green manuring a cocoanut estate weeding costs can be eliminated, the manure bill cut down appreciably, the nitrogen and humus content and the moisture holding capacity of the soil increased, its texture and tilth considerably improved, and its fertility maintained or even enhanced. A general improvement in the health and condition of the palms accompanied by increased yield will undoubtedly follow.

*Present-day Practice on Cocoanut Estates.*—It would, at this stage, be useful to compare the advantages of green manuring of cocoanut estates with the advantage of present-day estate practice. With the exception of those that have adopted green manuring cocoanut, estates in Ceylon can be placed in three categories from the point of view of general cultivation : (1) those that are weeded and ploughed periodically or ploughed periodically but not weeded ; (2) those that are neither ploughed nor weeded ; (3) those under grass not ploughed or those under grass periodically ploughed in.

In the case of the first class, provided the weeds are ploughed into the soil, estates on which this practice is followed should give fair yields. Organic matter is supplied by the weeds but the mineral plant food constituents of the soil will be gradually depleted, unless they are supplied by manures. Ploughing will encourage the fixation of the

free nitrogen of the soil by *Azotobacter* which derives its energy from the organic matter present in the soil. The amount of nitrogen fixed is more than counterbalanced by the amount taken up by the crop. The soil nitrogen will thus be slowly depleted. If no organic matter is added and the soil is regularly ploughed, its store of organic matter and nitrogen will be quickly exhausted owing to the activity of the micro-organisms in tropical soils. Yields are sooner or later bound to fall to a low level as a result of the loss of soil fertility and poor physical condition of the soil brought about by continuous ploughing. Clean weeding is not carried out on cocoanut estates because of the high cost, and on undulating land it is distinctly disadvantageous. In districts of low rainfall where weeds are allowed to cover the ground during drought, the crop will suffer owing to the loss of soil moisture through transpiration and yields will be affected adversely. On undulating and hilly cocoanut land in districts of heavy periodic rainfall, ploughing followed by heavy rains will cause soil erosion. Such lands should therefore be ploughed towards the end of the rains before the drought sets in or preferably planted with a cover crop and treated as detailed later.

In the second class, in which no cultivation whatever is carried out and no measures are taken to prevent the loss of soil moisture during drought or of the surface soil during heavy rains if the land is undulating, or to maintain soil fertility, the yields of palms will necessarily be low.

With regard to the third class, it may be said that many Ceylon estates are left under grass. It is commonly believed that grass has no deleterious effects on the cocoanut palm as palms are often found that give yields of 80 to 100 nuts and more though under grass. There is little doubt that if the grass were removed and the estates brought into normal cultivation higher yields of nuts would be obtained. Grass affects cocoanut palms (*a*) by depriving the palms of some of the soil moisture, especially during periods of drought; (*b*) by assimilating the available nitrate in the soil as well as a part of the manure applied to the crop; (*c*) as Howard at Pusa has shown, by preventing soil aeration and increasing the carbon dioxide content of the soil air. Carbon dioxide in excess may be toxic to the roots of the main crop. There is no evidence that other toxic compounds are found. If, however, the grass is ploughed in periodically at suitable times, no permanent harm can be done to the cocoanuts. On hilly and undulating land grass will prove useful against soil erosion but it should be ploughed in before the drought sets in and replaced by a leguminous cover,

*Decomposition of Green Manures in Soils.*—Provided there is sufficient moisture in the soil, the decomposition of green manures which is brought about by the soil micro-organisms will take place almost immediately. The final product is nitrate in which form most plants take up their nitrogen. The question has been asked whether in the process of decomposition of green manures, the available combined nitrogen of the soil is not assimilated by the micro-organisms bringing about the decomposition. It has been found by experiment that this will not occur unless the buried material contains less than about 2 per cent of nitrogen. As green manures generally contain over 2 per cent nitrogen on an air-dry basis, their nitrogen content is more than sufficient for the needs of the micro-organisms. The excess is, therefore, made available to the crop as ammonia and nitrate. When the material to be buried contains less than 2 per cent of nitrogen, as, *e.g.*, in the case of woody loppings or cocoanut husks which contain about .5 per cent nitrogen, the micro-organisms have to draw on the nitrate and ammonia reserves of the soil, the quantity present in the decomposing material being insufficient for their needs. A temporary loss of this nitrogen to the crop occurs, but the nitrogen assimilated is eventually made available to the crop. Loppings, therefore, should not be left to grow woody before they are ploughed in, as the more woody they become the less their nitrogen and the more their lignin contents become. Lignin decomposes only very slowly in the soil. The burial of husks in well drained, light and medium soils is advantageous to the crop owing to the quantities of humus they add to the soil on decomposition.

Experiments at Peradeniya have shown that maximum nitrification of green manures takes place in from six to eight weeks, but that subsequent to this the amounts of nitrate present in the soil vary, being largely dependent on rainfall. The more rain there has been during a period, the less nitrate is found in the soil at the end of the period. The experiments have also shown that, from the nitrogen standpoint, the direct effects of green manures in the soil are not appreciable after about six months.

In this connection reference may be made to a question frequently asked, whether green manure crops should be turned in green or dry. Work at Peradeniya on this point has confirmed the observations of previous workers that drying of green manures delays as well as hinders nitrification. Further, it was found that when green manure loppings were left to dry on the surface of the soil, great losses of nitrogen and to a smaller extent of organic matter, amounting in the case of the former to as much as 40 per cent of the nitrogen of the green manures,

may occur. Some of the nitrogen, however, is in the form of nitrate which is leached into the soil below. The losses are dependent on weather conditions and are greatest when there is an alternation of dry and wet weather. Decomposition also takes place most rapidly under these conditions.

*Practical Considerations.*—Under this heading the following will be discussed: (a) when green manures should be cut and turned into the soil and how they should be treated: (b) on what soils they should be grown and under what climatic conditions; (c) how a good growth of green manures can be obtained on poor soils.

(a) *When should green manures be cut?*—In general, previous work has shown that the highest percentage of nitrogen in green manures occurs at a comparatively early stage of their growth, but that the total nitrogen is greatest at or a little before flowering. A study is being made at Peradeniya of the change in composition and "decomposability" of green manures with age in order to determine the optimum stage for lopping. Green manures, especially in dry districts, should be cut towards the end of the rainy season when the showers alternate with dry weather and should be ploughed in at once. On sandy soils in districts where a long drought follows rain and it has not been found possible to turn in the loppings, the latter should be cut at the commencement of the drought and left as a mulch on the surface. On sandy soils moisture and not nitrogen is often the chief limiting factor of crop growth, and the mulch of green material will form a useful means of conserving soil moisture. It is preferable, however, to turn in the cuttings about three to four weeks before drought sets in, as by that time a certain amount of decomposition will have taken place and the decomposed material will have been able to retain some moisture for the subsequent use of the crop. On no condition should green manures be cut and forked into the soil during a drought, even at the beginning of it. This prohibition applies particularly to light sandy soils. The decomposition of green manures does not take place if the soil has insufficient moisture at, and subsequent to, the time of burying. If they are ploughed in during dry weather when the soil is dry, the materials remain undecomposed and leave large air spaces that cause loss of water by evaporation. It may be necessary in some instances to compact the soil after green manuring in order to minimize the losses of soil water and to establish capillarity in the soil.

(b) *On what soils should green manures be grown and under what climatic conditions?*—This is a point of great importance to cocoanut

planters. The greater majority of the soils of the cocoanut areas of the Negombo Chilaw and Puttalam Districts are light sandy soils which are markedly deficient in organic matter. The rainfall conditions are not ideal, especially towards Puttalam, and long periods of drought are not unknown. The question may well be asked, will not the light soils of these areas be deprived of the little moisture they contain by the growth of green manures? Work carried out at Peradeniya during the last three years on the soil moisture relationship of green manures and cover crops has shown that in the case of cover plants more moisture is lost to a depth of 24 inches during periods of drought from soils under cover crops than from bare soils during the first two years of the growth of the covers and that after this period the reverse is the case. This is due to the fact that in the early stages of the growth of the covers more moisture is lost from the soil through transpiration that is retained by the surface layer of decomposed organic matter or by the shade it affords. The reverse is the case once the cover is well established and a layer of organic matter has formed as a mulch on the surface. During the severe drought experienced in January and February of this year, moisture determinations were made on soil samples taken from the green manure plots at the Peradeniya Experiment Station. With regard to the cover crops, the previous results obtained were confirmed. In the case of the bush green manure, *e.g.*, *boga medelloa*, it was found that where the green manure was unlopped there was less moisture to a depth of 24 inches in the plots than in the controls, but where the green manure had been previously lopped and envelope-forked into the soil the plots had much more moisture than the controls. The importance of lopping the bush green manure crops before a drought is therefore clearly indicated. This applies particularly to bush green manures grown in the drier cocoanut districts.

With regard to the growing of green manures, it may be stated that, provided there is sufficient rainfall, they can be grown with advantage even on poor sandy soils. In the case of the latter, growing a green crop and turning it in will eventually give a soil of increased waterholding capacity enriched in nitrogen and humus. Where soils are poor and sandy and the rainy season is of short duration, a quick growing annual leguminous green manure crop should be grown. It should be cut and left as a mulch during the drought and ploughed in during the next rainy season, and the soil should be replanted with the green cover with the onset of the next rains; or, when possible, the green manures should be forked in early enough for decomposition to

have started before the drought sets in. It may be well to state that the barren sandy heaths of North Germany were reclaimed and made profitable by Schultz by growing lupines and ploughing them in along with phosphatic and potash manures. Suitable crops for the purpose of ploughing in on these poor soils will be dealt with later.

Some authorities seem to doubt the utility of growing green manures in dry districts and on very sandy soils. Though the doubt may be justified in the case of very dry districts in Ceylon, *e.g.*, part of the North Central Province, I do not think our cocoanut areas are so dry that such a system of green manuring as that already outlined cannot be carried out with advantage. It has been found in the arid districts of America that a minimum rainfall of 17 inches is necessary for green manuring to be practicable. Very few parts of Ceylon are as dry as this and all cocoanut districts get the benefit of at least one monsoon and most of both monsoons, so that during rainy weather green manuring can be safely adopted. On the better types of soils and in districts where the rainfall is adequate, green manuring is a simple matter and will be very advantageous.

Regarding the period of retention of green manures, it may be stated that, in general, perennial cover crops under cocoanuts should not be allowed to grow far too long without being ploughed in. The reasons for this are: (1) the soils on which these covers grow need periodical cultivation and aeration; (2) they get "sick" of growing one particular crop. For the latter reason, it is also advisable to have a rotation of green manure crops. The ploughing of alternate rows of the cover crop should be carried out once in two or three years in the case of both flat and undulating land. On the latter, the ploughing should be across the slope. Thus contourlike belts of unploughed cover will alternate with ploughed rows. Where the green manure crop is a heavy one, it should be cut up with a disc harrow or rolled before ploughing in. It is also advisable to plough in some cattle manure along with the green manures owing to the large number of bacteria present in the former which will hasten the decomposition of the latter. With regard to the shrubby types of green manures, care must be taken that the branches do not get too woody before they are lopped. Green manures can be forked into the soil along with artificial manures.

(c) *How can the good growth of green manures on poor soils be ensured?*—It may be found difficult to establish a green manure crop on poor sandy soils. Under these circumstances, attention may be drawn to the following practical points:—

(1) The green manure should be given a start by applying cattle manure to the seed bed. If cattle manure is not available, some nitrogenous manure, *e.g.*, a mixture of nitrate of soda and blood meal mixed with twice its weight of soil and applied at the rate of a handful or two per hole if cuttings are grown, will be found useful. Like other plants, leguminous plants require nitrogen in the early stages of their growth till their nodules are formed. Hence the need for this start.

(2) *Inoculation*.—Leguminous crops at times do not come up well in new areas to which they are introduced. This is because the soil does not contain the specific bacteria needed by the particular legume for the formation of the root nodules. In this case inoculation of the soil or of the seed will have to be carried out. There are three methods of soil inoculation of which the soil method is alone suitable for Ceylon conditions at the present time. It consists of broadcasting over the area to be planted, 300 to 400 lbs. of soil per acre which has been taken from an area on which the green manure it is desired to establish has been grown with success.

(3) *Manuring of green manure crops*.—In order to get a good growth of green manure crops manuring with potash and phosphoric acid should be adopted as the green manures have to compete with the main crop for these fertilizing constituents. As a result of manuring the bacteria are reported to become more active and able to enter the plants readily, and nodule formation is increased. The root growth of *Leguminosae*, in general, is stimulated by manuring with phosphoric acid.

(d) *Seeding, seed beds and cultivation*.—When planting green manures out for the first time a heavier seed rate than is normally required especially if seed is plentiful and comparatively cheap, is recommended. By this means a cover will be more quickly established and weeds more effectively suppressed. Generally speaking, green manure seed should not be broadcasted but should be planted in rows. A mixture of seed is said to give better results than seed of one plant. For cocoanut estates a mixture of shade and light-loving and of quick growing though short-lived and slower growing though long-lived plants will be found advantageous. In all cases, the seed bed should be carefully prepared. Seed is sown or cuttings planted in rows varying from 2 to 5 feet apart between the rows of palms. The planting should be carried out at the beginning of the rains. Weeding should be done in the early stages so as to give the green manures a good start.

*Green Manuring of Cocoanuts.*—Now that the advantages of green manuring, in general, have been indicated and some practical considerations have been dealt with, the question of the green manuring of cocoanuts, in particular, will be considered in detail. Many varieties of green manure crops have been found useful for new clearings and full-grown cocoanuts. Mention will be made of only a few. It is not proposed to deal with such considerations as seed rate, method of sowing or green manures suitable for a particular district. These are matters which have already been or will be dealt with in a general way. Such points will have to be investigated by the individual planter.

*Green Manuring of Cocoanuts in other countries.*—The practice of growing green manures under cocoanuts and oil palms is popular in the Dutch East Indies where it is doubtless, to some extent, responsible for the high yields of cocoanuts obtained. Most of the varieties now grown in coconut and rubber producing countries were first experimented with and grown on a large scale in the Dutch East Indies. In the Philippines cover crops are grown on every progressive estate. The green manures found most suitable are certain varieties of the lima bean (*Phaseolus lunatus*). This bean is a long-lived perennial of exceedingly vigorous growth which has been reported to be useful in exterminating illuk. It dies down in prolonged dry weather but comes up again with the rains. Unlike those of most green manure plants its leaves cannot be used as fodder owing to the prussic acid they contain. Other varieties found useful for cocoanuts in the Philippines are *Tephrosia candida* (*loga medelloa*) and *Tephrosia vogelii*. On the poor sandy coast soils of Porto Rico, species of *Mucuna* have been very successful. The growth of *Mucuna* is very quick and thick, and quantities of green material up to 6 tons per acre are obtained. Weed growth is effectively prevented. The leaves are rich in nitrogen and can be used as fodder.

Many varieties of green manures have been found suitable for cocoanuts in Malaya. Among others, *Centrosema pubescens*, *Calopogonium mucunoides*, *Dolichos hosei* (*vigna*), *Centrosema plinieri*, *Pueraria phaseoloides*, besides bush varieties like *Tephrosia candida* (*loga*), *Tephrosia vogelii* and *Crotalaria* spp. Some of these will be referred to in greater detail later. In India *Vigna catjang* (cowpeas) and *Dolichos uniflorus* (horse-gram) are grown successfully, both as catch crops and green manure crops.

*Green Manuring of Cocoanuts in Ceylon.*—Green manuring of cocoanuts was undertaken as early as 1905 at the Experiment Station, Peradeniya. The crops tried were cowpeas, groundnut, soy bean, *Crotalaria* spp.

and boga. Cowpeas gave very good results, and so did boga and *Crotalaria*. Soy beans were not a success, due doubtless to the deficiency in the soil of the specific bacteria associated with this crop. It has been found in America that inoculation of soy beans is always necessary before the crop can be introduced into new areas. Groundnut is very useful as a green manure owing to its rapid growth but is not so successful as a catch crop owing to damage by rats which also attacks the cocoanuts.

*Green Manures for Young Coconut Estates.*—In young clearings where the rainfall conditions are satisfactory, the growth of a cover crop is very advantageous for reasons already stated. The bush varieties, e.g., boga, are not entirely suitable as they are inclined to become too dense and to compete with the young coconut plants unless they are grown in rows 6 feet wide and are regularly lopped. In regard to all cover plants in young cocoanuts, it has to be emphasized that they must never be allowed to climb over the young cocoanuts even for a short period; if they do, the latter will suffer a setback. The following will be found useful and can be recommended for young coconut areas in Ceylon:—

*Calopogonium Mucunoides.*—This is a quick growing green manure with a tendency to climb. It grows well on most soils but requires well-drained soil. It is very suitable for young clearings. During periods of prolonged drought, it has a tendency to die out, but with the advent of the rains a fresh cover is obtained. It is best sown in rows 3 to 5 feet apart. It requires weeding in its early stages. A good cover about two feet thick can be obtained in about four months. It is a good seeder and dies out in twelve to eighteen months. It can also be grown under old cocoanuts which do not give much shade, but it does not thrive so well as in the open. Some of its disadvantages for old cocoanuts are: (1) its growth is so thick that it is difficult to find the nuts which have been picked; (2) it harbours snakes. The latter disadvantage applies to all green manures.

*Mucuna spp.*—These plants have already been dealt with. After they have formed a good cover in new clearings, they should be ploughed in and followed by a more permanent cover, e.g., *Centrosema pubescens*.

*Centrosema pubescens.*—This is a twining creeper requiring a fairly good soil. It is rather slow in growth but forms an excellent cover in about five or six months; difficulty may be experienced at first in establishing it. If it is grown after a crop like *Mucuna* has been ploughed in, its growth will be quicker. It stands drought admirably. It does not thrive under heavy shade but it grows well under the light shade of cocoanuts.

*Dolichos hosei* (commonly known as *vigna*).—*Vigna* is more suitable for heavy shade but does well in young clearings. It is a very useful cover for old cocoanuts as it does not make too thick a growth and hence does not cover the nuts. The disadvantages with *vigna* are that it is rather difficult to establish on eroded hilly land, needs constant weeding and dies down during drought. It is advisable to establish the plant in nurseries, and to give it a start under old cocoanuts by applying some nitrogenous or cattle manure.

*Pueraria phaseoloides* (*javanica*) is a strong twining cover and is useful for young clearings, but it must be kept away from the young palms. It dies down in drought. It does best under shade and is very suitable for old cocoanuts. It is better suited for heavy land than for sandy soils.

*Centrosema plumieri*, *Dolichos lablab*, *Dolichos biflorus* (horse-gram) have also been recommended as green manures for young cocoanuts.

*Arachis hypogea* (*groundnut*).—Groundnut can be grown either as a green manure crop or as a catch crop and is very suitable for dry districts. Trials should be made with the different varieties of groundnuts as a catch crop in young and old cocoanuts. The cake obtained after the extraction of the oil can be used as manure and the leafy material can be turned in as green manure or fed to cattle. The crop is ready for harvesting in six or eight months. The disadvantage of this crop is that it attracts rats.

*Vigna catiang*, *Vigna sinensis* (*cowpeas*).—Cowpeas are suitable for young plantations and old cocoanuts. The cowpea is a quick-growing annual which forms an excellent cover in three to five months. It thrives on the poorest land and stands drought well. It is therefore very suitable for Ceylon cocoanut lands. It has been successfully used at Peradeniya as a green manure for cocoanuts and also in the Kurunegala District. On an estate in the latter district, a three months' growth of this crop under old cocoanuts, not only produced an appreciable difference in the appearance of the palms but also increased the nitrogen content of the soil. The yield of green material obtained has been as much as six tons per annum.

*Soja max* (*soy bean*).—Trials with varieties of the soy bean should be made in young clearings as well as under old cocoanuts. There are more than 400 varieties of this bean in existence. It is a herbaceous annual of erect growth, varying in height according to the species. It is particularly resistant to drought and will thrive on most soils except the very poor ones. Inoculation is essential when this crop is grown

for the first time. Like groundnut it can be treated both as a catch crop and a green manure crop.

Of the bush varieties of green manures suitable for cocoanuts, *Tephrosia* spp. and *Crotalaria* spp. are most suitable. *Clitoria cajanifolia* is also a suitable hedge plant for cocoanuts. Of the former *Tephrosia candida* (boga medelloa) is perhaps the best for Ceylon conditions; hence its popularity as a green manure for cocoanuts. If the land is rich boga will, unless lopped, grow too tall and affect the young cocoanuts adversely. It should always be sown in rows and never broadcasted. Boga can be grown on hilly land in contour hedges across the slope. On poor and badly drained soils on which it is difficult to establish boga, the following methods will be found suitable: (1) a drain should be cut and the soil heaped in mounds over husks. The seed is then sown on the mounds, a little artificial or cattle manure being added if necessary. It can also be grown on the mounds of contour terraces of cocoanuts; (2) the application of cattle or buffalo manure in lines between the rows with liming and forking before sowing the seed. Boga gives a very heavy yield of loppings rich in nitrogen and organic matter and also in mineral, because it is so deep-rooted. It stands lopping well and can be grown in most coconut districts. Like all shrubby green manures it must be cut before drought sets in towards the end of the rains. It is preferable to fork it into the soil if a sufficient interval of time between the turning in and the onset of the drought is anticipated. In case a sufficiently early forking is not possible, the bushes should be lopped at the beginning of the dry period and the loppings left as a mulch on the surface. In this case, the soil moisture must be conserved even at the risk of incurring appreciable losses of nitrogen. The leafy portions and the less woody material should subsequently be forked into the soil at manuring time in the manure trenches. When shrubby green manures are cut at other periods, the cutting should be done just before or at flowering. The disadvantages of shrubby green manures are the difficulty of supervising labour and of gathering the crop. Other varieties of shrubby green manures suitable for cocoanuts young and old, are *Tephrosia vogelii*, *Cajanus indicus* (dhal), *Crotalaria usaramoensis* and *Crotalaria anagyroides*. The latter are quick growers and give large amounts of organic matter. They need frequent lopping but die off comparatively soon.

*Green Manures for Old Cocoanuts.*—The shrubby green manures have been dealt with. Of cover crops, *Centrosema pubescens*, *Centrosema plumieri*, *Dolichos hosei*, *Pueraria Phaseoloides*, *Phaseolus lunatus*, *Vigna catiang* (cowpea), *Arachis hypogea* (groundnut), *Mucuna* spp. will

grow successfully if the shade is not too heavy. *Colopogonium mucunoides* is also suitable if the shade is not heavy. *Desmodium polycarum* has been found to be a very good green manure for cocoanuts in the Kurunegala district. Especially on poor soils, *Mikania scandens* can be left where it grows if it cannot be replaced by a green manure crop. It must however be ploughed in before the drought sets in. It is a non-leguminous twining weed common on estates and is useful for suppressing other weeds, *e.g.*, illuk. It has been found useful in Malaya and the Philippines as a cover crop for cocoanuts. In general it may be stated that any leguminous plant growing on a coconut plantation should be encouraged and, if indigenous legumes grow well in the neighbourhood, attempts should be made to introduce them on the estate. In the case of non-leguminous plants which grow well outside estates, *e.g.*, wild sunflower, it would be advantageous to lop them before they have flowered and to use the cut material for green manuring cocoanuts.

*Treatment of Green Manures prior to drought.*—The general treatment of cover crops under cocoanuts before a drought, in districts of average quality soil and with average rainfall, is a comparatively simple matter. Most covers die down during a prolonged drought, and the decayed leafy material obtained forms a very good mulch. If, in addition, light harrowings are periodically given the palms should not be affected to any great extent by drought. Immediately the rains start, the covers come up again. In the case of covers which stand drought well, experiments at Peradeniya already referred to indicate that once the cover has been well established less moisture is lost from the covered area than from the bare soil. In districts with a good rainfall, though some moisture will be lost from the soil through cover crops in the early stages of their establishment, there will not be any permanent ill-effects on old cocoanuts. In young plantations it would perhaps be useful to grow a mixture of drought-resisting and non-resisting covers. Where the soil is very sandy and the rainfall satisfactory, the growing and forking in of quick-growing annual covers, *e.g.*, cowpeas, groundnuts and *Mucuna spp.* are advised, followed, when the soil is sufficiently enriched with organic matter, by the growth of a more permanent cover. In the case of sandy coconut soils in dry districts quick-growing annual crops should be grown in the rainy season and ploughed in towards the end of the rains. Boga medelloa or other bush green manure should also be grown and the loppings cut and left as a mulch on the surface at the beginning of the drought. After a few years of this treatment the question of the establishment of a permanent cover should be considered,

It is advisable to grow both cover crops and the shrubby forms of green manures on cocoanut estates. The latter primarily supply the soil with organic matter and the former secure to the soil and crop the benefits already explained.

*Conclusion.*—In the preceding pages, an endeavour has been made to indicate the need for, importance of, and advantages to be derived by, green manuring Ceylon crops in general and cocoanuts in particular; the difficulties likely to be met with and the measures necessary for surmounting them; the possible disadvantages of green manuring under certain soil and climatic conditions and how they may be minimized to some extent; the varieties of green manures suitable for different soil and climatic conditions. It is left to the individual estate owner to ascertain by experiment which green manures suit his conditions best. It is regretted that little information is available as regards increased yields of nuts and profits derived from green manuring. It, however, will soon be forthcoming. There is little doubt that judicious green manuring of cocoanuts will pay. If green manuring can have had such markedly good results in the case of tea and rubber, it is more than likely that it will have the same results in the case of cocoanuts. It has been widely adopted in progressive cocoanut-growing countries, *e.g.*, the Dutch East Indies, the Philippines and Malaya. The universal adoption of the practice should eventually result in increased yields and improved quality of nuts and in a permanent improvement of the condition of cocoanut estates in Ceylon. It, therefore, offers a means of combating in one direction the present depression of the cocoanut industry. By green manuring, the weeding bill is lessened; and appreciable reduction in the manure bill can be effected without a corresponding fall in yield of crop or loss of soil fertility; a permanent increased soil fertility is brought about and the value of the estate is enhanced; the palms are brought into better condition, become more resistant to disease and may be expected to give increased yields. It is true that for a year or two a certain amount of expenditure is necessary, but it will be more than compensated for by savings in the weeding and the manuring bills.—*The Tropical Agriculturist*, Vol. LXXIII, No. 3.

### **Breeding Bulls for Mysore Raiyats.**

The Government of Mysore have sanctioned the establishment of a Cattle Breeding Station at Parvathrayankere about one mile from Ajjampur, Kadur District. This station will be used for the purpose of raising Amrut Mahal bulls for distribution in the villages of the State,

Work has already been commenced on the station but as it is proposed to distribute bulls at three years of age, it will be three years before animals actually raised on the station will be available for distribution.

The Amrut Mahal Department has a considerable number of breeding bulls available each year but very few of these are being used by Mysore raiyats for breeding purposes. The reason for this lies in the fact that the bulls are not domesticated and so are difficult to manage and are at times not satisfactory. To overcome this difficulty and to tide over the time till the station will be able to supply bulls raised at Parvathrayankere, selected young bulls three years old are being selected from the Amrut Mahal herds and are being trained on the station. There are, at present, fifty of these selected bulls available for distribution. These will be distributed under the following conditions which have been approved by Government:—

(1) The purchasers shall neither castrate nor sell the bulls without the consent of the Director of Agriculture within five years from the date of purchase.

(2) A record of coverings shall be kept by the purchaser and this record as well as the bull shall be available at all times for inspection by Officers of the Civil Veterinary Department, the Amrut Mahal Superintendent and the Live-Stock Officer.

(3) Should the bull prove to be unsatisfactory in service within a period of one year from the date of purchase and should it appear on inspection and enquiry by one of the above-mentioned officers that the deterioration is not due to neglect or mismanagement on the part of the purchaser, the latter may be provided in exchange with another bull from the stock on the station.

It is considered desirable as far as possible to distribute these bulls through the District Boards. All the District Boards have already been requested to sanction a sum of money which will enable them to bear half the cost of each bull distributed in the district. Several of the District Boards have already agreed to set aside a sum of money for the purpose and it is hoped that all the Boards will do so. It is proposed during the present year to reserve forty bulls for distribution through the District Boards to Village Panchayets, Co-operative Societies or individuals whom the Boards consider likely to make good use of the animals. Village Panchayets, Co-operative Societies or individuals who are not prepared to wait till the District Boards can take action and who are prepared to pay the full cost of a bull will be supplied direct under the conditions mentioned above.

These bulls are now available for inspection in the Station and intending purchasers, whether individuals or organizations, will be allowed to make their choice as long as the supply lasts. Applications should be sent without delay to the Director of Agriculture, Bangalore or to the Manager, Government Cattle Breeding Station, Ajjampur Post.

LESLIE C. COLEMAN,  
*Director of Agriculture.*